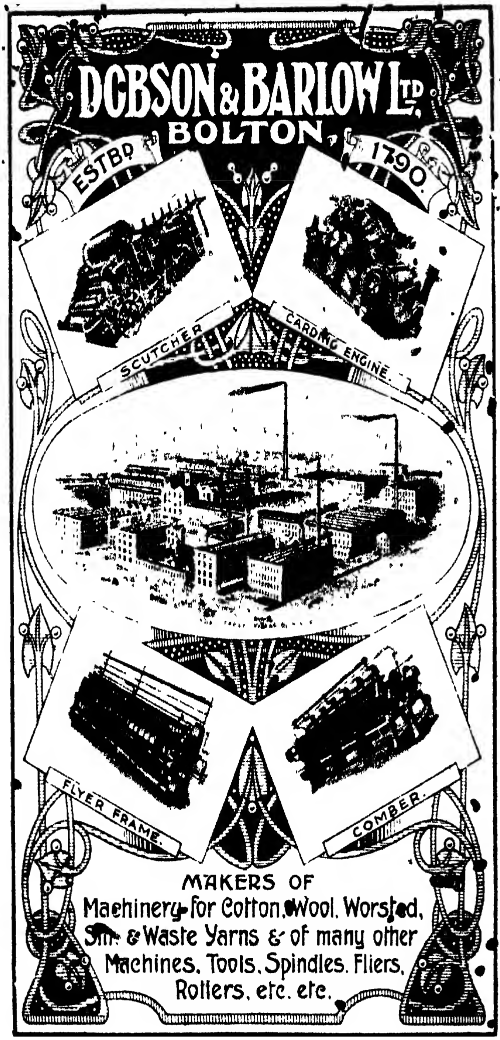

DOBSON & BARLOW Ltd.
BOLTON,
ESTBD 1790.
SCUTCHER
CARDING ENGINE.
FLYER FRAME.
COMBER.
MAKERS OF
Machinery for Cotton, Wool, Worsted,
Silk & Waste Yarns & of many other
Machines, Tools, Spindles, Fliers,
Rollers, etc. etc.

WM. SCOTT TAGGART, M.I.MECH.E.

CONSULTING ENGINEER,

22 BRIDGE STREET,

MANCHESTER.

TELEPHONE
No. 3815 CENTRAL, MANCHESTER

TELEGRAMS SCOTTAG, MANCHESTER.
CODES - - A.B.C. AND PRIVATE.

LANS AND ESTIMATES PREPARED FOR TEXTILE MILLS.

REPORTS ON THE WORKING OF MILLS.

TESTS OF TEXTILE MATERIALS.

ADVICE AND REPORTS ON PATENTS.

PLANS AND ESTIMATES FOR POWER PLANTS.

REPORTS ON THE ECONOMICAL WORKING OF POWER PLANTS.

TESTING OF COAL, WATER, ETC.

COTTON SPINNING

MACMILLAN AND CO., Limited
LONDON · BOMBAY · CALCUTTA · MADRAS
MELBOURNE

THE MACMILLAN COMPANY
NEW YORK · BOSTON · CHICAGO
DALLAS · SAN FRANCISCO

THE MACMILLAN CO. OF CANADA, Ltd.
TORONTO

COTTON SPINNING

BY

WILLIAM SCOTT TAGGART, M.I.MECH.E.

MITGLIED DES VEREINS DEUTSCHER INGENIEURE.

AUTHOR OF

'COTTON MACHINERY SKETCHES,' AND 'COTTON SPINNING CALCULATIONS'

VOLUME II

INCLUDING THE PROCESSES UP TO THE END OF FLY-FRAMES

WITH ILLUSTRATIONS

FIFTH EDITION

MACMILLAN AND CO., LIMITED
ST. MARTIN'S STREET, LONDON
1919

First Edition 1897
Second Edition 1901
Third Edition 1905
Fourth Edition 1908
Fifth Edition 1913
Reprinted 1917, 1919

PREFACE TO FIRST EDITION

THIS, the second volume, reprinted from *The Textile Mercury*, brings the subject of cotton spinning down to the end what is generally termed the preparing processes. It includes all the machinery and manipulations between the card and the self-actor or ring-frame. As the operations included in this section have a most important influence upon the future character of the yarn, it has been considered necessary to go a little more deeply into the subject than is usually thought necessary. Attention has not only been confined to the principles underlying the actual processes themselves, which is of itself a most interesting and important feature, but in conformity with the objects that prompted the writing of the first volume, an effort has been made to give to the mechanical details an interpretation which some of them have hitherto not possessed.

It was with this purpose in view that the writer remarked in the preface to the first volume that the book would not be one of "mere description." The remark was meant to

be applied to the whole subject of cotton spinning; in this volume a reasonable claim may be made that it is justified, and the third volume, dealing with the spinning processes, will still further prove the writer's objects and method.

The fact that at present the education of the average reader is not sufficiently thorough to enable him to understand fully some aspects of the question discussed is no reason why an attempt at completeness should not be made. Such a state cannot last very long. The systems now being adopted in our technical schools will raise the general level of intelligence, and, moreover, a feeling will grow that we "must" so raise ourselves if we are to maintain the practical superiority over our competitors which we at present claim.

W. S. T.

Bolton, 1897.

PREFACE TO SECOND EDITION

Improvements and corrections have been made and the drawings renumbered, so that the book is entirely self-contained. This system of dividing the subject of cotton spinning into three volumes has been justified: it fits in with the arrangements for study and the examinations, and meets the requirements of those employed in the various departments of the mill.

W. S. T.

1900.

PREFACE TO FIFTH EDITION

THE book has been brought up to date and considerable additions made both to the matter and the illustrations. The author and publisher hope that these improvements will cause it to maintain its career as a useful handbook to the student and the practical man.

WM. SCOTT TAGGART.

BOLTON, 1913.

CONTENTS

CHAPTER I

CHAPTER II

CHAPTER III

ILLUSTRATIONS

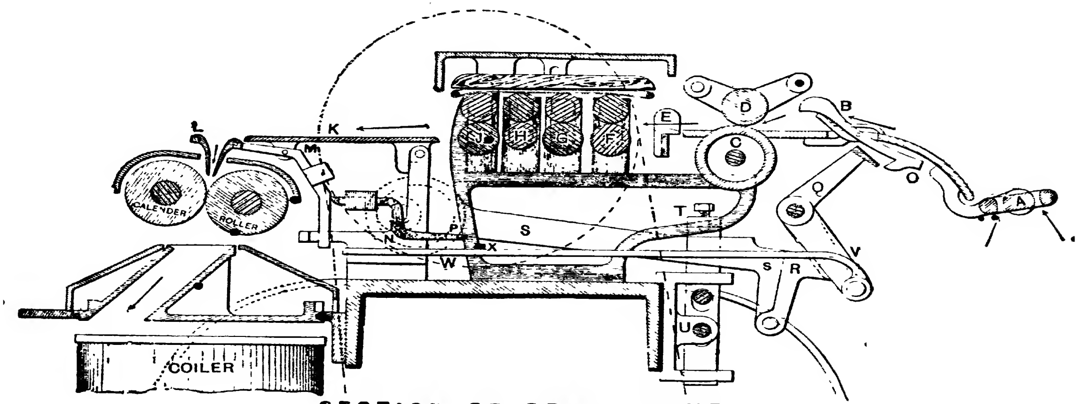
CHAPTER I

DRAWING

The Web from the Card.—A close examination of the web or film of cotton as it comes from the doffer of the carding engine will disclose an arrangement of fibres quite contrary to what might at first sight be expected when the action of the card is understood. Instead of order, a very irregular result will be noticed. The specific action of the condensing process between the cylinder and doffer, however, will account for much of the crossed condition of fibres, and the stripping operation of the comb will still further increase the irregularity of their disposition in the web. It is this irregularity of arrangement that enables the cotton to be stripped from the doffer and carried forward to the calender rollers. Any parallelisation in such a thin web would render it practically impossible to free the fibres from the doffer—much less to carry them away, as at present. A point, however, that must not be overlooked, is seen very clearly in the web as it approaches the calender rollers of the card. Between the doffer and the calender rollers there is always a draft; and, moreover, the mere fact of causing a web of cotton, which is the full width of a card, to converge very quickly

towards a point, will make every fibre in the web partake of the convergence, in whatever crossed condition it may be. This constitutes, of course, a distinct tendency to laying the fibres side by side, which is further augmented by the action of the draft in pulling the fibres apart. Such an action as this cannot be performed without straightening them considerably, the friction existing between them being sufficient to cause the individual fibres to straighten in sliding over one another. Although this is apparently an insignificant action, it is in reality the very keynote of the process of drawing; for while in this process great reliance is placed upon obtaining a regular sliver, it must not be overlooked that success in the operation almost depends entirely upon the fibres being laid parallel, which state is brought about because of the friction between them during the drawing action being sufficient to straighten them out.

Description of the Drawing-Frame.—Before entering upon a detailed investigation of the drawing-frame and its action, a general description of the machine will be given. To do this a drawing is represented in Fig. 1, which represents a section, through the chief features, of a well-known type of frame as made by Dobson and Barlow. The full cans of sliver are taken from the card and put behind the draw-frame, so that the sliver can be passed up in the direction of the arrows through holes in the guide-plate A. On going forward, each sliver passes over a spoon-shaped guide B, and on between two rollers C and D, whence it is guided to the back-roller F by means of the traverse guide E. Four successive lines of rollers are now passed, during which the sliver is considerably drawn out or attenuated in consequence of each roller having a greater surface speed relative to the one next



SECTION OF DRAW FRAME

Fig. 1.

to it. This is an essential feature of the machine, and it is from this fact that the name "drawing-frame" is derived. On emerging from the roller J the drawn sliver is taken over a polished plate K, through the funnel L, and on between the calender rollers to the coiler. The above is a general description; we now enter into details. The guide-plate A is arranged so that it can be carefully adjusted according to the position of the cans from which the slivers are taken. Large quantities of waste are easily made by carelessness in setting it, due to the breakages that occur through too great a drag being put on the sliver in passing through the holes. The draw-frame is arranged so that each sliver that enters the rollers is drawn out four to eight times its original length, and four to eight slivers are passed through together, so that, although each one is so lengthened out, their combination at the funnel L, through which they pass, produces a sliver which differs very little in weight or length from any one of the entering slivers; it is more regular in substance, and its fibres are drawn out, comparatively speaking, parallel to each other. (The principles underlying these actions are explained on page 14.) Otherwise there is no noticeable difference between a sliver fed at the back and that delivered at the front of the machine. Six ends or slivers are generally passed through, and in such a case the total draft between the rollers will be six. Each drawing-frame is split up into what are termed **heads,** a head being that portion of the rollers through which a group of slivers pass. For instance, if six slivers, side by side, pass through the four lines of rollers and are combined into one at the funnel, that section of the machine is called a **delivery,** and a **set** of deliveries is called a **head.** As a rule, there are from two to four heads in a complete draw-frame (see Figs. 2, 3,

and 4). This diagram illustrates three methods of arranging draw-frames. In Fig. 2 we have the **tandem** system in which the deliveries are all one way. It will be observed that there are 24 cans behind the machine; six ends pass through each of the four deliveries, so that only four ends emerge at the front. These ends would be taken to another passage of draw-frames, and possibly to a third. Fig. 3 illustrates the **alternate** system, in which the slivers follow the arrow, and an extension of this

Fig. 2. Fig. 3.

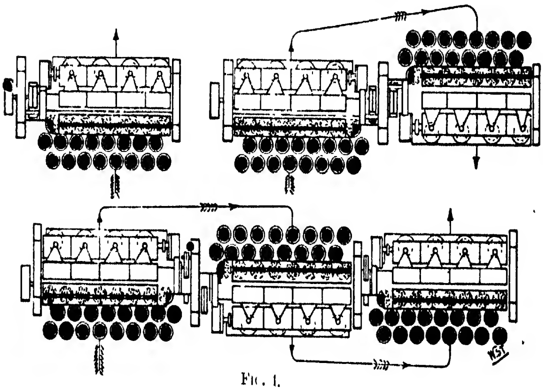


Fig. 4.

arrangement results in a modification known as the **zig-zag** system. These different systems are the outcome of convenience to the work hands, economy of labour, and suitability of driving, as well as a saving in room and power. It must be understood that a wide variation may exist in the size of draw-frames. Each head may have eight deliveries, instead of four, as shown; there may be three heads of seven or eight deliveries; in fact, there is scarcely a limit to the utilisation of the draw-frame for its purpose of drawing and doubling slivers. The length

of rollers in each delivery varies from 15 in. to 18 in.; this length refers to the top rollers. Each of the bottom rollers is generally made in one length, or in sections pieced together so that they revolve as one length. These bottom rollers are fluted—that is, grooves are cut therein lengthwise—in order that a grip may be obtained of the cotton as it passes through, and also that this grip shall prevent the cotton from slipping or being drawn from between the rollers in consequence of the draft. The number of the flutes, of course, varies in different frames, but they are usually as follows:—1 in. diameter, 36 flutes; $1\frac{1}{4}$ in. diameter, 45 flutes; $1\frac{3}{8}$ in. diameter, 50 flutes; $1\frac{1}{2}$ in. diameter, 54 flutes. The arrangement of the flutes, especially where the top rollers are covered with leather, is such that they have a slightly decreasing pitch on the circumference. It will be seen that by this means the chance of the flutes making corresponding grooves in the leather, or actually cutting it, through continual working, is considerably reduced when compared with the effect produced if the flutes be all pitched alike. The general term used to designate this kind of fluting is **hunting**, and its effect is similar to that of the 'hunter cog' adopted by clockmakers, and formerly by engineers, in having the number of the teeth of wheels in gear so arranged that the same teeth come into touch with each other only after a number of revolutions.

Rollers.—It will readily be seen that since the drawing action of the machine is such an important factor in its usefulness, every means must be adopted to enable it to perform this part of its work perfectly. The grip of the various pairs of rollers, or their power to draw the fibres over each other without breaking or straining them, must be carefully attended to, for carelessness in this respect will

simply mean waste, and considerable irregularity in the resulting sliver.

The top rollers, although heavy, are not sufficiently so to dispense with additional weighting, and, generally speaking, draw-frame rollers are weighted by some system of supplementary weights. As a rule, dead weights are adopted, *i.e.* weights sufficient for the purpose are hung by means of wire or cast-iron hooks from each end of the roller (see Fig. 5). In such a case the weights would probably vary from 14 to 25 lbs. if each end were weighted separately, but very frequently one weight is used for both ends; when this method is adopted the weights must be double what they were in the first case. The actual weight required depends upon the special circumstances in each mill, and is largely a question of experience. Many people would adopt weights of something like the following:—Front roller, 22 lbs.; second roller, 17 lbs.; third roller, 17 lbs.; and fourth roller, 17 lbs. Here the front roller is naturally more heavily weighted than the others, because of the greater bulk of cotton going through at this point; but the others are all alike in weight, the draft between them not being so great, and consequently there is no great necessity for any variation. There are, however, many authorities who advocate different weights on each line of rollers, and they would most probably arrange them as follows:—Front roller, 20 lbs.; second roller, 18 lbs.; third roller, 16 lbs.; and fourth roller, 14 lbs. It may also be noted that some arrangements for the lower class cottons and heavy slivers have slightly heavier weights than for the finer classes of cottons. It is, however, very much a question of experience, and in deciding upon the question a full consideration must be given to all the factors of the case.

Leather Rollers.—The leather covering of the top rollers has already been mentioned. The adoption of such a covering on the top rollers of cotton machinery is necessitated by the fact that two iron rollers revolving in contact, with pressure upon them, would crush such delicate fibres as those of cotton when it passed between them. The top roller is therefore almost invariably covered with some elastic or yielding material. Usually it is first covered with a specially woven woollen cloth, which is firmly cemented to the iron surface of the roller; this gives a good elastic foundation. Over this is tightly drawn a thin leather covering, which thus forms a smooth, regular, and firm surface, which is capable of gripping the slivers and yet at the same time yielding sufficiently to prevent damage to the fibres. The maintenance of a perfectly round leather-covered roller is of great importance in the draw frame, and under all circumstances it ought to be maintained. One way of doing this has already been indicated in the use of the variable pitch in the flutes of the bottom roller, but this is only applicable whilst the machine is working. When a stoppage of the machine takes place for any length of time, such as a week-end or holidays, the top roller can be damaged considerably by the effect of the hanging weights producing a depression in the yielding material of the top roller. This, when the machine works again, is easily seen in the slightly eccentric running of the roller, and its effect is to produce irregularity in the sliver. In most mills, when a stoppage occurs, the weights are disconnected from the rollers, and this can be done either by going round to each of the weights and uncoupling them separately, which means a great waste of time and energy, or by the use of some system of raising all the weights in one head at once. Such a system is shown in the

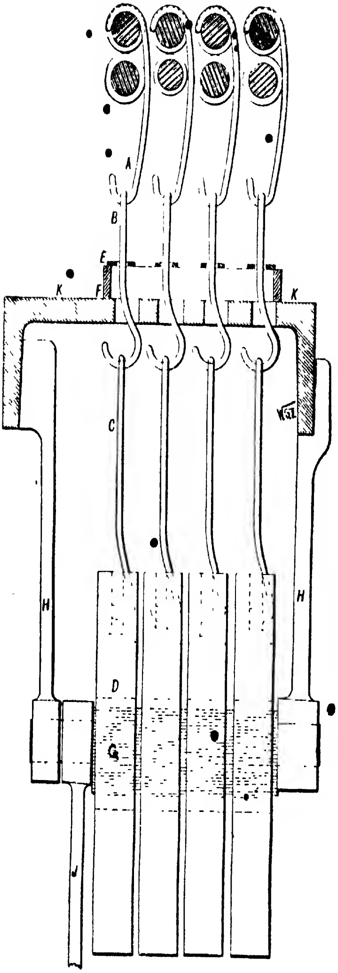


FIG. 5.

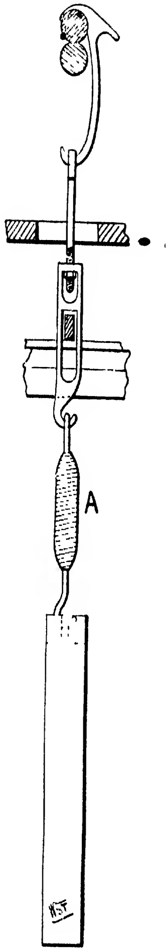


FIG. 6.

accompanying drawing (Fig. 5). The four lines of rollers are shown with the hooks A hanging from the top rollers. To these hooks other hooks B are attached, and to these are connected the weight hooks C, to which the weights D are hung. In each weight is a specially formed hole, through which passes an eccentric G, so as not to touch the weights in any way whilst they hang from the roller. The eccentric is carried at each end by brackets H bolted to the beam. On one end is connected a handle J, conveniently placed for being used when required. A quarter turn of this handle turns the eccentric sufficiently to bring it into contact with the weights on the upper part of the hole, and a slight continuation of the movement will naturally raise them bodily, and so relieve the pressure on the rollers. The elongated cast-iron washer F, together with the small washers E, are used to prevent the hooks B falling through the holes in the beam whenever they are uncoupled from the weight hooks.

A further refinement in weighting is adopted in some mills, and consists in making the hook C in two parts, and placing a spring between them. This has the effect of neutralising any slight shock that might come upon the rollers, its purpose being simply to act as a cushion. Fig. 6 shows a modified form of this system, as made by Brooks and Doxey, and the effect of the spring A is to reduce vibration due to the high speed of the roller.

Loose Boss Rollers.—We have treated of the top roller so far simply as a roller covered with leather and working in slides or bearings at each end. Such a roller is called a solid roller, and is represented in the drawing (Fig. 7). They are, as a rule, used only for the last three lines of rollers. The front line of rollers is now almost invariably made with loose bosses. This type, introduced by Evan

Leigh, is shown in Fig. 7 in section, and from it we see that there is a centre spindle having a barrelled body, over which is fitted an outer shell which runs loose on the centre roller; and since it is only in contact with it at the points A, friction will be considerably reduced. Such a roller can easily be lubricated, the tendency of the oil being to run down to the points A and stop there; the oil is consequently prevented from getting on to the cotton as it passes through. The centre roller does not revolve, so that no lubrication is required on its pivots. It is much easier in

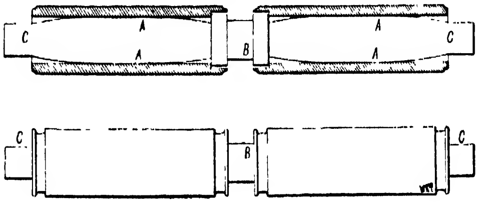


FIG. 7.

a roller of this class for the outer shell to revolve over the stationary centre roller, especially when such a thorough lubrication can be obtained; consequently it has become very generally used. In spite of these advantages, however, there are many who still prefer the solid form of roller. It is contended that the very ease with which it revolves is a disadvantage, inasmuch as the grip will be reduced, and to restore it heavier weights must be used. It is also claimed that a better draft can be obtained with a solid roller; but when a practical examination is made of the matter the contentions are found to be of no value whatever. In the facility with which the loose boss roller works there is an advantage that has not yet been mentioned—that is, the

prevention of the possibility of the top roller remaining stationary, if only for a moment, whilst the bottom roller is still running. When such a thing happens the slivers that are passing at the time are practically crushed or very much weakened by the rubbing they receive. This cannot occur with loose boss rollers, and from this fact alone there exists a strong recommendation for their use.

Loose Bush Rollers.—Another form of top roller, which has even greater advantages than the loose boss type, is one in which the roller itself is solid, but each end works in a loose bush; a good surface for lubrication is thus provided, as well as greater facility for the oiling, and friction is almost eliminated. It was formerly the rule to have double boss rollers in the draw-frame, but this practice has fallen almost out of use. Their advantages over single boss rollers was apparent—for instance, there were fewer hooks, wires, and weights, and consequently the cleaning of the machine was a much easier matter and quickly performed; the weighting was also much more simple, the machine was less costly, and in the lubrication less oil was required, this, of course, reducing the probability of staining the slivers. The single boss roller, however, in spite of the above, has one great advantage which the double boss does not possess, viz. each sliver, or group of slivers, is treated by itself, independently of others, so that more regular yarn is produced. In connection with this question of loose bush rollers, one well-known firm (Brooks and Doxeys) writes as follows:—"Where manufacturers prefer double boss rollers we strongly advise the front top roller being made with loose bosses, as these obviate cutting the roller leather arising from one of the bosses being larger than the other to defective covering. For single boss rollers, how-

ever, which have the advantage of only two selvages instead of four, we advise the use of loose bush rollers." A single boss roller would be weighted from each end, and if 16 in. long on the boss, the leather-covered portion would be about $8\frac{1}{2}$ in. long. The double boss roller is weighted from its middle, and the leather-covered portion on each side of the hook would be about 5 in. long.

It is the practice in most mills to have the bottom rollers case-hardened in the necks, whilst in some the whole of the bottom rollers are case-hardened throughout. As a result they are rendered stiffer and stronger, and more capable of resisting torsion, while the flutes are less likely to be damaged either through accident or carelessness.

Diameters and Setting of Rollers.—Some attention will now be paid to the sizes and the conditions of setting the rollers, together with the circumstances that must be taken into account in their arrangement. The importance of the relative position of the rollers to each other, according to the cotton being worked, cannot be overestimated. If the operation is carelessly performed, nothing can afterwards remedy the bad work that is sure to result. There is one broad principle that must always be used as a guide in setting the rollers. The last pair of rollers must be so set that the distance apart of their centres just exceeds the average length of the staple of the cotton passing through. The previous pair of rollers are then set $\frac{1}{8}$ in. farther apart than this, and the back pair $\frac{1}{8}$ in. farther still, so that if the staple used is 1 in., then the distances would be $1\frac{1}{8}$ in. between front and second, $1\frac{1}{4}$ in. between second and third, and $1\frac{3}{8}$ in. between third and back. The above is a good plan to follow, but variation may be introduced and the distances made slightly less, especially where the cotton is soft and not heavy or wiry. The following sketches, with

dimensions, will convey a good idea of the arrangement of the rollers and their sizes for different classes of cotton. The dimensions of the top rollers in each case represent the

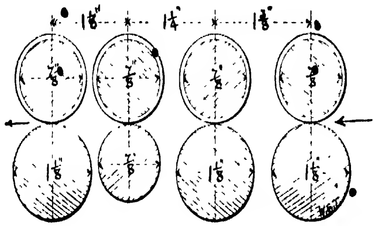


Fig. 8.

diameter before it is covered. Fig. 8 is for Indian cotton, Fig. 9 American cotton, and Fig. 10 Egyptian and Sea Island cotton.[1]

The following summary will represent the main points that are deducible from what has already been said :—The

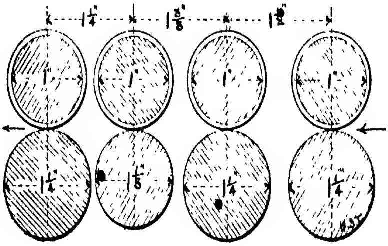


Fig. 9.

short-stapled cottons require small rollers and short distances between them ; as the staple increases in length the rollers must be enlarged and the distances increased. If a heavy sliver is being used, the distances between the centres must

[1] Vol. III. gives more complete details on this subject to which reference may be made.

be greater than when a finer sliver is passing through. If the draft is rather small, or, as it is sometimes called, "easy," and the sliver is fine, the distances between the rollers can be a little less than when the draft is a high one and the sliver heavy. If the staple of the cotton is irregular, the best thing to do is to bring out the roving as fine as possible and use easy drafts. When a big draft is used, the rollers should be run slowly. As the draft is lessened a quicker speed may be run; but it should always

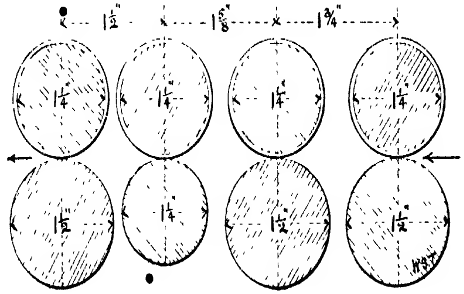


FIG. 10.

be remembered that a large percentage of waste will result if a big draft and a big speed are run together.

Principles of Draft.—Now that we understand the general arrangement of the machine and the disposition of the rollers, it will be beneficial at this point to make an examination of the principles upon which the action of the machine is based. In the draw-frame there are two absolutely distinct operations, each one serving its own purpose, and producing a result totally different from the other. By combining the two operations into one process, we obtain the desired result of parallelisation of the fibres and regularity of the delivered sliver. The two actions will be considered in their order.

It has already been mentioned that the sliver passes through four pairs of rollers, each pair of which, after the first, is accelerated in speed, the result being an attenuation or drawing-out of the fibres. It is advisable to understand this clearly. In the first place, the sliver is fed to the first pair of rollers, which carry it forward; the second pair of rollers now grip the cotton, and since they are revolving at a greater surface speed, they will take the cotton forward quicker than it is being given to them. It will be readily understood that if both pairs of rollers held the same fibres of cotton at the same time the fibres would naturally be broken; it is to prevent this happening that the rollers are set apart a little wider than the length of the fibre. The fibres under these conditions, therefore, yield among themselves under the action of the quicker roller, and in doing so their contact with each other sets up sufficient friction to cause each fibre, as it is pulled along, to straighten itself out into a comparatively level condition. The surrounding fibres are all being acted upon in the same manner, so that although the sliver as a whole is gradually being made thinner, its fibres are also being made to lie in the same direction as the length of the sliver. There is another point that it is as well to understand. By referring to the remarks on the setting of the rollers, it will be noticed that the fibres, when passing from one pair of rollers to another pair, are not immediately gripped, but lie free, as it were, between the two pairs. Such fibres are in reality being drawn in almost the same way as if they were gripped, because their ends are being acted upon by the fibres that are passing through the rollers; in addition, the friction thereby set up carries them forward, and in doing so drags the other ends over the fibres that are being delivered, and so straightens them. The reason why the different pairs of

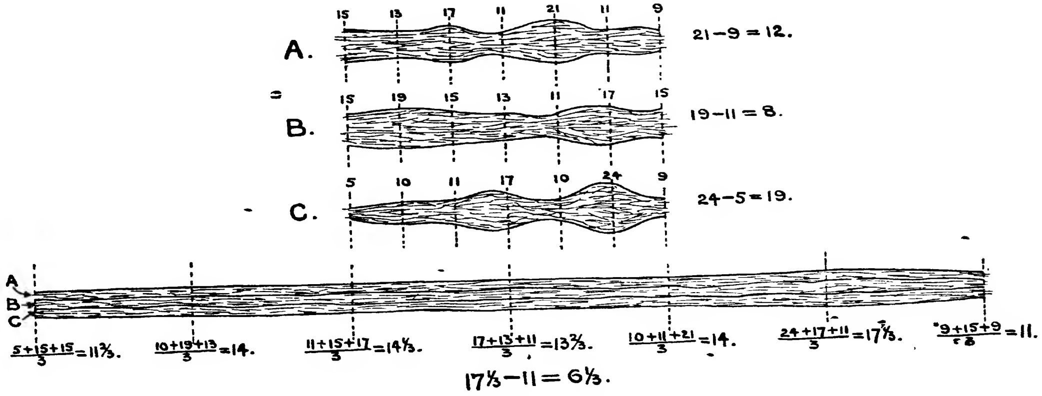
rollers are not uniform in their distance apart is not far to seek. As the sliver from the card or comber is passed through, the first two pairs of rollers must be wide apart, because the sliver is thickest, and also, for the same reason, the least drawing action must be performed, so as not to damage the fibres, but to act on them gradually; the time of leaving the grip of one pair and being gripped by the next pair must therefore be sufficient to permit of this being done. The sliver is considerably reduced by the time it reaches the last, or, as it is frequently called, the front pair, so here we have the least distance and the greatest draft consistent with good work.

Nothing has been said so far about this attenuating process having the effect of obtaining any species of regularity in the thickness of the sliver, and to a thoughtful reader it is quite obvious that no kind of regularity can possibly be obtained by a purely drawing-out process as it exists in the draw-frame. If a thick and thin sliver were passed through the machine, their relative condition would be practically the same when delivered, no matter what amount of draft be given. As an illustration we will take an exaggerated example of an irregular length of sliver. Suppose we had a length of sliver 2 ft. long, each 6 in. of which had a diameter of 1 in., $\frac{3}{4}$ in., $\frac{1}{2}$ in., and $\frac{1}{4}$ in. respectively, and this were passed through a machine having four of a draft, the result would clearly be that each 6 in. would be lengthened to 2 ft., and the cross section of each sliver would be reduced to one quarter of what it was on entering; we cannot reasonably expect any other result. The fibres would certainly be in a more parallel condition, but the irregularity, so far as thickness is concerned, would still exist, because nothing has been done to lessen it. On the other hand, great irregularities

can be introduced by carelessness in the drafting and weighting of the rollers.

The laying of the fibres in parallel order is a very important duty in the draw-frame; but the equalisation of the sliver is equally important. The process of doubling the slivers enables this condition to be obtained, and it must be repeated as often as is found necessary to obtain the required degree of regularity with the least strain on the fibres. The principle underlying the action was touched upon when dealing with the doubling of the laps in the scutcher (see vol. i.); but here we will go into the matter a little more fully, because it is the very foundation upon which regular yarn is made. If a number of slivers, say six, that may be very irregular in diameter, were placed side by side or made into one thick sliver, it is generally assumed that there would be great probability of the thick and thin places coming together; and the assumption would be a correct one even if it depended only upon experience for its sanction. One may make thousands of tests from the carded sliver, knowing beforehand its variation from regularity, and if six are simply placed together the regularity will be improved. It may and does happen that two, three, or even six thick or thin places come together, but the chances of their doing so are very remote, and do not neutralise the argument that there is an enormously increased probability of greater regularity occurring. We will try to demonstrate this by an example, and whilst taking numbers that are large and give a wide variation, it will readily be understood that, whatever numbers are taken, similar results will be given. Suppose a sliver was very irregular, and its different thicknesses were represented by the numbers 1, 2, 3, 4, 5, and 6. Such a sliver would be six times as thick in one place as in

another. Now take, say, three slivers like this one, and place them side by side, and let us consider the question whether the irregularities will be reduced by so doing. Granted that the irregularities are equally disposed in each sliver, we can see at a glance that there is only one position they can occupy side by side so as to obtain their greatest irregularity, and that is when the thickest and thinnest places all come together; but when we know that the possible combinations of the different thicknesses in the three slivers are innumerable, it is easy to see that the probabilities are all in favour of regularity. A very simple illustration will make this point perfectly clear. A diagram is given in Fig. 11 and portions of three irregular slivers are shown at A, B, and C. Measurements of these slivers were made at seven points in their length, and the figures over each point represent the diameters to scale. It will be noted that greatest difference between the thickest and thinnest place is 12. Similarly the difference in B and C is 8 and 19 respectively. Now if these three slivers are placed together and then drawn out to three times their length we shall obtain a sliver D which is equal to A, B, and C divided by 3. If the diameter numbers on A, B, and C are totalled at each respective line and divided by 3 we obtain the diameter number of the new combined sliver D; and it will be noted that the new diameter numbers only represent a difference between the thickest and thinnest of $6\frac{1}{3}$, so that the new sliver is greatly improved in regularity upon each of the original three slivers composing it. If more slivers are combined the probabilities increase, and when we consider that irregularities in a sliver are also very irregular in their position along the sliver, we increase still more the chances in favour of regularity. Upon all this, the fact should be considered, that when six slivers



A.
15
13
17
11
21
11
9
21−9 = 12.
B.
15
19
15
13
11
17
15
19−11 = 8.
C.
5
10
11
17
10
24
9
24−5 = 19.
A
B
C
$\frac{5+15+15}{3} = 11\frac{2}{3}$.
$\frac{10+19+13}{3} = 14$.
$\frac{11+15+17}{3} = 14\frac{1}{3}$.
$\frac{17+13+11}{3} = 13\frac{2}{3}$.
$\frac{10+11+21}{3} = 14$.
$\frac{24+17+11}{3} = 17\frac{1}{3}$.
$\frac{9+15+9}{3} = 11$.
$17\frac{1}{3} - 11 = 6\frac{1}{3}$.

FIG. 11.

are put through the draw-frame, six of the resulting slivers are passed through another head, and six slivers that are the result of the second drawing are passed through a third time. Each time they have been submitted to a draft of six, so that the total doubling the sliver has received is $6 \times 6 \times 6 = 216$. The diagram in Fig. 12 will

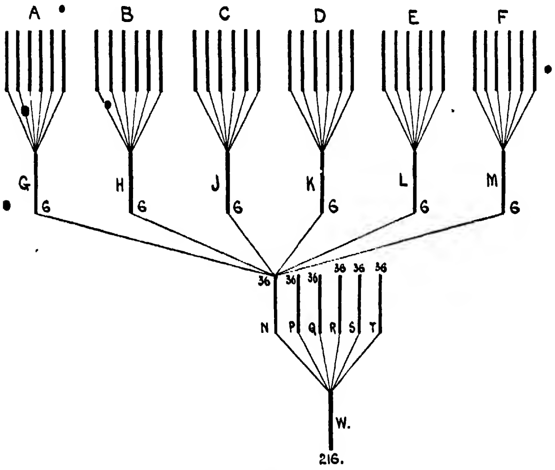


FIG. 12.

perhaps make this clear. A represents six card slivers, and they are doubled, drawn out, and form one sliver at G. A similar thing happens at B, C, D, E, and F, and results in single slivers at H, J, K, L, and M. The six slivers G, H, J, K, L, and M are doubled and drawn out to one at N, so that N is the result of 36 original card slivers being doubled together. Each of the slivers P, Q, R, S, and T also represents 36 original card slivers, so that if these six slivers N, P, Q, R, S, and T are doubled together, the resulting sliver W is the result of doubling 216 original card

slivers. We can thus easily realise that in the operation of doubling we have a process upon which every reliance can be placed in obtaining regularity of the sliver, and that the principles upon which it depends are perfectly sound.

Stop Motions.—It is quite manifest that the value of doubling will depend very much for its success upon the continuous feeding to the rollers of the same number of slivers. If six slivers are fed this number must be maintained, for

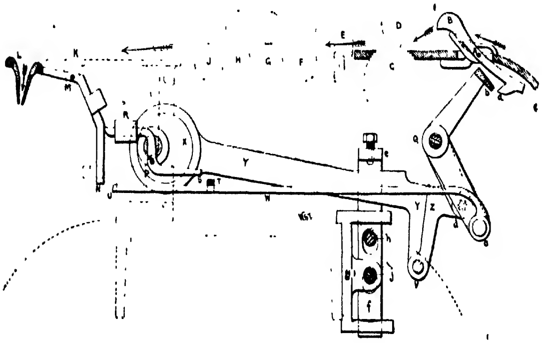


FIG. 13.

if one of them broke, and it was not immediately pieced up, there would be a weak spot in the delivered sliver of over 16 per cent less than the adjacent portions; so it is imperative that this should be avoided, and consequently in all draw-frames means are taken both at the front and back of the machine to prevent the possibility of such a thing happening. A variety of mechanical methods are employed to serve this purpose, one or two of which will now be given. Fig. 13 shows the first example. After the slivers have passed through the sliver plate from the cans, each one is conveyed over a lever B, centred on a pivot at A.

The upper portion is formed as a kind of spoon, so shaped as to keep the sliver in position, and the lower part is made with a hook-shaped projection "a." The spoon lever B is so pivoted as to be almost balanced. Its heavier portion is, however, at the bottom. When a sliver is passed over the spoon there is sufficient weight, together with the tension in it, to counteract this weight and cause the upper portion B to be depressed; and so long as a sliver is going forward or its tension is maintained, the lever

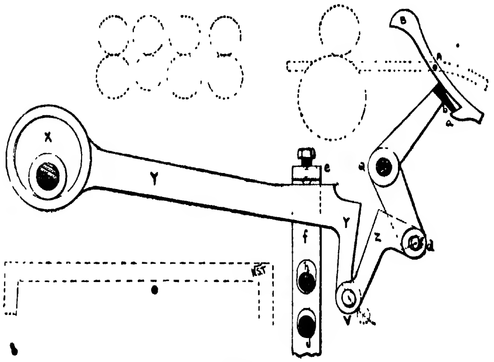


FIG. 14.

will always occupy the position shown in the drawing (Fig. 13). Directly an end breaks, through a knotted portion not being able to pass through the sliver plate, and also in consequence of weak spots existing in the sliver, or when a can runs empty, the upper part is relieved of its weight and the lower portion "a" immediately falls, and in doing so occupies a position which prevents a vibrating arm "b" from working. This causes almost instantly the stoppage of the machine. Its precise action is worthy of a detailed examination, so, although the sketch (Fig. 14) is similar to the drawing (Fig. 13), it is reproduced here stripped of the

accessories, and the stop motion only shown distinctly. An eccentric X, acting through the arm Y and the bell lever on the shaft Q, gives to the vibrating knife "b" its reciprocating motion. Under normal conditions of working "b" passes through a short arc of a circle, and in doing so just misses the hook portion "a" of the spoon lever. It will be noticed that the eccentric arm Y is in two parts, Y and Z, and that they are connected by a pin at the centre V. The end "d" is in connection with the vibrating lever working on the shaft Q. The whole arrangement is so balanced as to offer very little resistance to the free movement of the two portions of the eccentric arm, and it therefore works as if it were one piece. If anything, however, interferes with this freedom of movement—for instance, when an end breaks and the hook part "a" of the spoon lever B drops and prevents the motion of "b"—something must yield, for the eccentric continues to work. This yielding takes place between the two parts of the eccentric arm, and results in the lifting up of Y bodily. In this action it is brought into contact with the upper portion "c" of a knocking-off slide "f," which keeps the strap on the fast pulley. As "f" is lifted up, the shaft J, which is kept in position by the slide, is released, and a strong compression spring placed upon it, acts through suitable stops, on the strap-fork rod "h," and so changes the strap from the fast to the loose pulley, which stops the frame. The machine cannot be started again until the cause of stoppage is put right. Fig. 14 is given to represent the position occupied by the eccentric and levers when an end breaks. The eccentric is in its highest position, whilst the centre V has also been raised from its normal position. This clearly lifts up the arm Y, and when this is effected the stoppage of the machine is a comparatively

simple matter. This motion is generally called the **Back-stop** motion.

There is also in front of the machine another stop motion, its object being to prevent a decreased number of slivers passing through to the coiler. This reduction in the sliver may occur either through breakage or roller laps, *i.e.* when a sliver sticks to the leather of the roller and begins to be wound round it. Crossed and knotted portions may occur, and these also stop the machine. The slivers coming from the front roller pass over the plate K (Figs. 1 and 13) and down through the funnel L into the coiler can. The funnel L is carried by a lever centred at M, and is so balanced that any diminution of tension of the slivers will cause the funnel to lift up, which causes the other end N to fall, and in doing so it comes in the way of a vibrating feeder bar W. This bar is connected with the eccentric arm, and is actuated from it. Directly, therefore, that its motion is stopped, the two portions Y and Z separate, as in the back motion, and the frame stops. If from any cause too much sliver is going through the funnel L, it will do so with difficulty and naturally depress it. This depression raises one end R of a lever, which is centred at P, and depresses the end S. A stop pin T on the vibrating feeder bar is by this means prevented from passing forward, and as a consequence its movement is stopped, and, through its connection, the machine also. The position of the weight R on the lever is used to regulate the amount of sliver that can be passed through the funnel without stopping the frame.

Another form of stop motion, made by John Hetherington and Sons, is shown in Fig. 15; enlarged views are also given of some of the details. The action is as follows;—The sliver passes forward from the cans in the direction of

the arrow, and is guided to the "single preventer" rollers G and H by the guide J. From here it moves towards the rollers over the spoon F; through this spoon, means are adopted for stopping the machine when an end breaks or a can runs empty; the enlarged view will enable the action to be understood. As the sliver goes forward, the spoon F, fulcrumed on the knife edge O′, is pressed down upon the

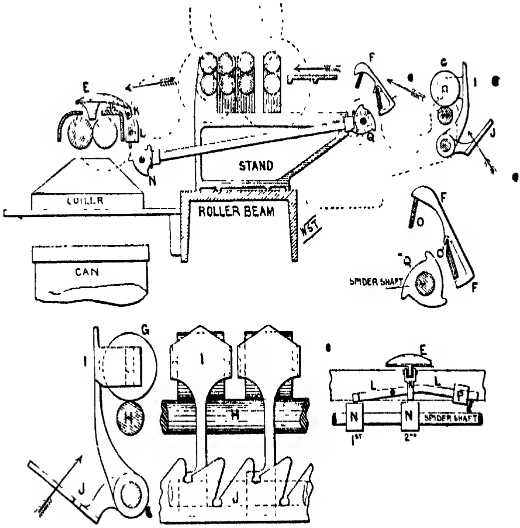


FIG. K.

rod O, and in this position its other end is kept out of the way of a revolving spider Q. If an end breaks, however, the pressure is taken from the spoon, and its lower end, being the heavier, falls and comes into contact with the revolving spider Q; through inclines on the face of the spider a sliding motion is produced which, actuating a stop rod, moves the strap on to the loose pulley, and so stops the machine.

The front stop motion acts as follows:—The sliver passes through a funnel E which is pivoted as shown in the drawing. It is balanced by means of the weight P, and this can be so carefully done that if too thick or too thin a sliver is passing through, the funnel will fall or rise. For instance, if a knot or twisted sliver tries to go through it will depress the funnel, this will raise the link K and so act on the lever L (see enlarged drawing) as to bring one end of it into contact with the 1st spider N and stop the machine. On the other hand, if too thin a sliver passes through, the link K will fall and come into contact with the 2nd spider and also stop the machine.

It is very desirable, whenever an end breaks, that the piecing should be a direct one. It is not sufficient that the two ends are placed just in contact; there must be no interval whatever between the two. The fibres of one end must interlock with the fibres of the end to which it is pieced. To do this effectually we must arrange the machine so that the breakages occur at points where the piecings can be performed successfully, and with a minimum of trouble. If a breakage of sliver happened just as it was entering the rollers there would be considerable difficulty and loss of time, as well as waste, in making a successful piecing; so, to prevent this, all draw-frames are now made with what is generally termed a "single preventer" motion. This usually consists of two rollers (see Figs. 1, 13, 14, and 15) placed between the sliver plate and the spoon levers. The bottom roller is driven at a slightly slower speed than the back roller, so that the sliver between them has a small draft and is in tension. Any breakage that occurs will almost invariably be between these rollers and the cans, so that immediately the broken end passes between the two rollers the spoon is relieved and the machine stops.

The piecing at this point is easily effected. The stop motion also acts much quicker with the single preventer. The tension of the sliver between it and the back roller is always uniform, and is sufficient to keep the spoons in their correct position, as they act instantly when the tension is removed. Without this motion the tension would be very irregular, since the sliver coming from the can would one moment be tight and the next very slack, and formerly it was no uncommon thing for the machine to stop simply because of slack sliver.

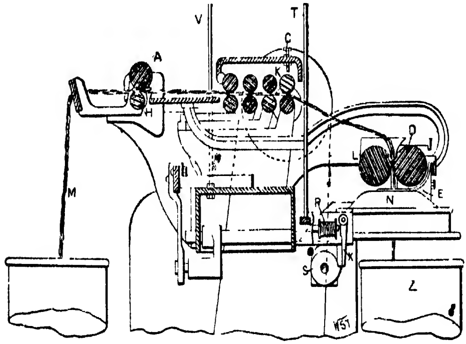


FIG. 16.

Owing to the multiplicity of parts and the separate motions necessary to obtain thorough control of the machine by means of the mechanical arrangements just described, a large firm of machine-makers, Howard and Bullough, introduced several years ago a method of attaining the same, or even better results, by means of electricity. In order to understand the question fully, a drawing of a section of the draw-frame is given in Fig. 16. Here the sliver is shown in its passage through the machine, and it is quite apparent that the whole arrangement is of the

most simple character. The principle upon which the action of the machine relies for its effective working is based upon the important fact that cotton is a very good insulator, or, in other words, a non-conductor of electricity. Electricity, generated by means of cells placed near the machine or wherever desirable, is conducted by wires to certain parts of the frame. This electricity is rendered inoperative so long as the opposite poles of the current are not allowed to be brought into contact with each other. Directly one part of the machine having positive electricity is connected to another part having a negative current, the current begins to circulate, and if means are taken to introduce in the path of the current some appliance like the electro-magnet, the machine can be readily stopped by its action upon catches or otherwise. In the drawing the single preventer motion is shown at AH. The bottom roller is continuous, and is supplied by electricity from one pole of the battery. The top rollers are in short lengths, each length having two slivers passing under it. They are connected to the opposite pole of the battery, and insulated from the rest of the machine. So long as the top and bottom rollers are kept apart by the slivers which pass between them nothing will happen, because the current is disconnected, and therefore powerless; but immediately a sliver breaks, the rollers come into contact, and the current begins to flow through the electro-magnet P. This, as a consequence, is made sufficiently powerful to draw on one side a hanging catch X, which is thus brought into the path of a revolving cam S. The motion of the cam is stopped by this action, and, in stopping, it actuates the strap shifter in such a manner as to stop the machine. When the sliver breaks in front of the frame, after passing through the rollers, the stop motion is arranged to be actuated from

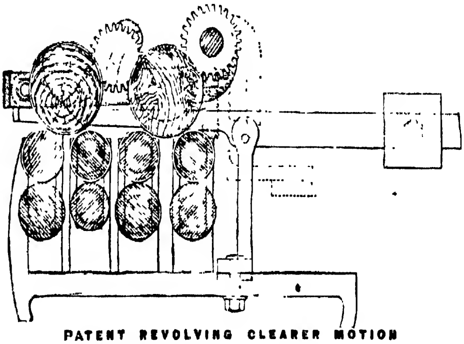
the calender rollers L and D. These are insulated in a similar manner to the back roller motion A and H, and the slivers in passing between them prevent the flow of the current; but when a breakage does occur the rollers come together, and the machine is instantly stopped by the same electro-magnet and catch as in the first case. When the sliver wraps round the roller, either top or bottom, its immediate effect is to lift up the top roller. This completes the circuit by bringing roller K into electrical contact with the top clearer at the adjusting screw C, and so puts into operation the electro-magnet P. A similar result happens when the can is full. In this case the machine is stopped through the excessive pressure of the sliver in the can lifting the tube wheel slightly, and thus connecting the two poles of the battery.

Whatever may be said against the introduction of electricity into a room which, in the majority of cases, is already greatly charged with the fluid in a most inconvenient and unmanageable form, its results in the attainment of the desired ends that necessitated its introduction have caused it to be held in high repute by all who have had occasion to use it.

Top Clearers.—We now come to another detail of the draw-frame, viz. the top clearers, and they are an essentially important feature of it. Owing to the large amount of friction that is set up in a cotton mill, and the practically complete insulation of the whole ironwork in the building, the electricity that is generated is gradually accumulated until its effect on the various machines and the fibres of cotton is to tend to draw them away, with the result that these fibres cause a wiriness to appear which, unless suitable

humidifying influences are brought to bear on it, will continue in the subsequent stages. In the draw-frame the slivers are untwisted and relatively parallel to each other, so that this effect of electricity is seen in the ease with which the fibres attach themselves to the rollers and are carried round. If this continues for some time the loose fibres will accumulate, and eventually, by gravity or other disturbing force, fall back on the slivers and be incorporated in them, to their considerable detriment. It is, therefore, necessary to clear the rollers by some continuous process, so that as little labour as possible is introduced into the operation. One method of doing this is by means of what is termed a stationary flat. A sketch of this form is shown in the section of the draw-frame in Fig. 1. It consists of a piece of flannel attached at the front and back to a portion of wood in such a manner that the weight of both wood and flannel rests on the top rollers. The roughness of the flannel naturally clears the rollers of the loose fibres and particles of dirt that may adhere to them. In the arrangement there are no means taken to carry away what is generally called the flat waste, so it gathers into lumps, and at last will drop into the slivers unless great care is taken in cleaning them at regular intervals of about two hours. To avoid this unnecessary labour, and the probable spoiling of the cotton, several good types of top clearers have recently been introduced, which minimise to a very large extent the inconveniences associated with the stationary flat. A typical form, made by Dobson and Barlow, is given in the accompanying drawing (Fig. 17). It consists essentially of two wooden rollers covered with flannel, one of which rests between the front and second rollers, and is driven positively at such a speed as to prevent any damage to the leather rollers upon which it rests, and

yet so that it can clear them of their adhering fibres. The other roller simply rests between the third and back rollers. This roller will receive a turning motion, due to the fact that it is in contact with two rollers that are running at different speeds. The friction set up between them clears the leather. It is quite obvious that the revolution of the two clearer rollers will, in addition to their cleansing action, also form around themselves in a kind of lap all the dirty and loose cotton they collect. There can, therefore,



PATENT REVOLVING CLEARER MOTION

FIG. 17.

be no accumulations with their attendant evils. The stripping of the roller is an easy matter, and only requires to be performed about once a week. This is a decided improvement upon the frequency of stripping which was necessary in the earlier form noted above. It will be noticed that the weight of the flannel-covered rollers must be carefully adjusted, for it is bad policy to allow the full weight of any arrangement, unless it is very light, to rest indiscriminately upon the top rollers. The requisite arrangement in the apparatus is attained by the employment of a balanced lever, pivoted as shown, one end of which

rests under the frame carrying the rollers, whilst the other end is weighted with a movable weight. By this means the pressure required on the rollers is readily obtained.

Two other examples of clearers are given in Figs. 18 and 19. Fig. 18 consists of a flannel A carried over rollers and driven positively; the friction of the flannel on the top rollers gives a cleansing action. The flannel is automatically cleaned by means of a reciprocating knife B resting on the flannel and being carried by an arm C centred at the end D of a lever carried on a stud at E. An eccentric gives to the end F a to-and-fro movement which is transferred to the knife B, and which enables the knife to scrape

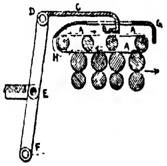


FIG. 18.

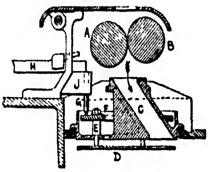


FIG. 20.

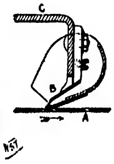


FIG. 19.

off the fibres, etc., collected by the flannel. This clearer is generally known as Ermen's Clearer. An improvement on it, known as Colling's Clearer, is shown at Fig. 19; the arm C has a double knife B, the fly and dirt scraped off the flannel A is collected in the receptacle shown, and thus prevented from escaping and falling down on to the emerging slivers.

Full Can Stop Motion.—Fig. 20 represents a full can stop motion: it is very simple in principle and quite effective. As the can fills, the sliver presses upwards against the plate D, and this moves a plate F also upwards. In contact with the plate F is a pin G, which is forced up until it comes into the path of a reciprocating rod H which

it stops, and this stoppage, through the usual means, leads to the stoppage of the machine.

A full can stop motion is also made which acts when a certain length of sliver has been put into the can; a worm and worm wheel, actuated from the rollers, cause a stop-piece to move forward on a screw until eventually it comes into the path of the reciprocating rod through which the stop motion acts.

Metallic Rollers.—As their name implies, these rollers are of metal and intended to displace the top leather-covered rollers of Draw and Fly frames. They are fluted and spaced in such a manner that they practically gear with the bottom rollers, so that as the sliver passes between the two it receives a crimping effect. Claims are made that this is an advantage and adds to the elasticity of the yarn, but it is an extremely doubtful advantage even where it exists. A further claim made is that an increased production is obtained from the same speed of roller. This may be considered. In the first place the increased length delivered, due to the crimping, implies an increased speed of spindle, in order to put in the desired twists per inch. Moreover, because of the increased length, the draft must be regulated by running the back roller at a higher speed. These are two palpable results to be taken into account if a comparison is to be made between a machine working with and without metallic rollers. The question of their advantage in higher production may therefore be considered as a very small matter and of no practical value in a mill. It has also been found that the passage of the sliver between the flutes has a crushing effect on the fibres, though this has been modified in the most recent form of roller. The older form of metallic rollers simply consisted in the flutes, of the top roller resting in the spaces of the

bottom roller. The next improvement was to prevent this by turning collars on each end of top and bottom rollers; these were of such a size that when the collars were in contact, the tops of the flutes of one roller did not come into contact with the bottom of the spaces of the other roller. This, however, did not prevent the crushing effect, so a further improvement was to cut at each end of each roller flutes and spaces that rested on and in each other; but in the middle part of the roller, through which the sliver passed, a less diameter with smaller flutes and larger spaces was made; this naturally is the best form of the arrangement.

A section of Asa Lees' draw-frame is given in Fig. 21, and whilst it follows the usual design the *stop motions* are sufficiently interesting to be illustrated and described. The motion shown in the drawing is driven from the coiler shaft to a wheel on which is cast an eccentric A, on which fits the strap B, with its rod C weighted at D, with an extension on which is fixed a stud E. This stud E enters a V-shaped slot in the lever F, whose fulcrum is at G; the other end of lever F is extended to I. The weight D maintains the stud E at the bottom of the V slot, and the lever F will simply oscillate to and fro freely. If the end S of the spoon or the end of the trumpet lever H comes into the path of the vibrating ends I or J, then the V-shaped end of F will be locked, and the stud E, being free to move, will slide up one of the grooves in the V, and on coming into contact with the arm K move its other arm out of the locking position on the stop rod L, and so stop the machine.

In Fig. 22 we have Dobson and Barlow's improved design of the machine illustrated in Fig. 1. It will be noticed that the rollers D, C take up the slivers from the cans and that the single preventer is placed between these

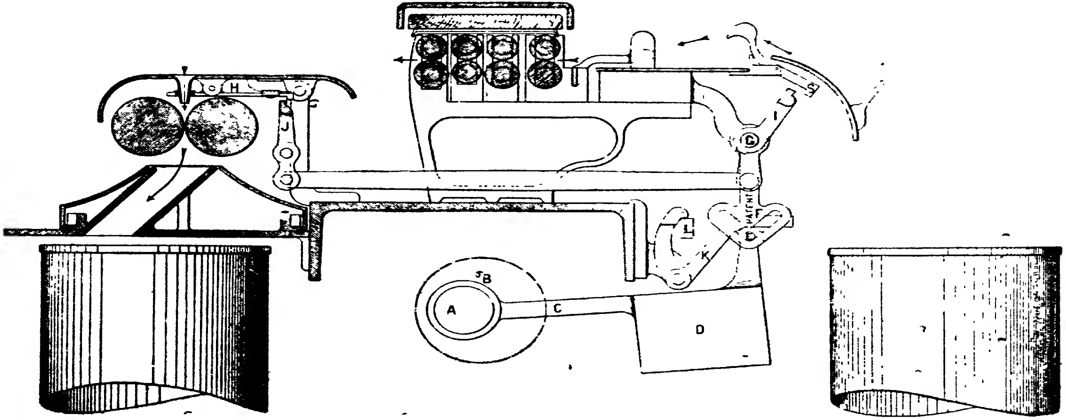


Fig. 21.

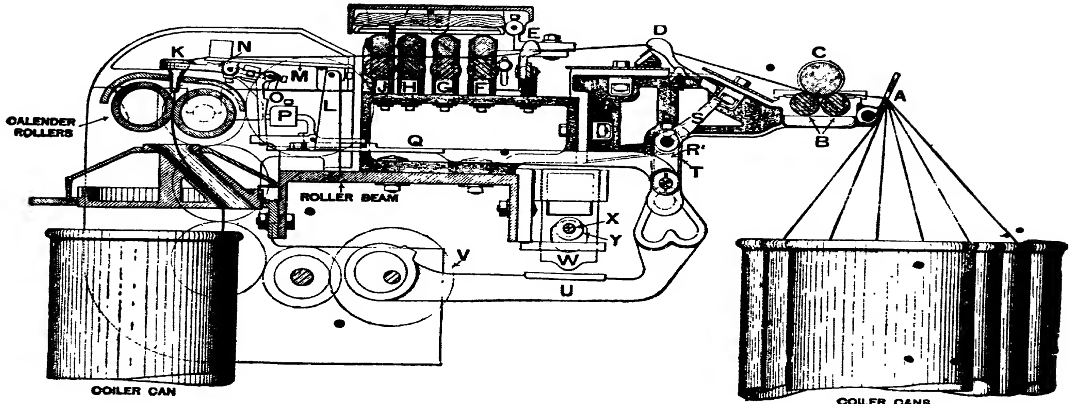

CALENDER ROLLERS
K
N
M
O
P
L
J
H
G
F
E
D
C
A
B
S
R'
T
Q
ROLLER BEAM
X
Y
W
V
U
COILER CAN
COILER CANS

FIG. 22.

rollers and the back roller F. Every sliver is thus treated alike and all have equal tension, so that a more sensitive action is introduced on the spoon B, and the trouble caused by mere slackness of the sliver in the cans is no longer a source of annoyance through stoppage of the frame.

Calculations.[1]—We now come to deal with the question of gearing, and the changes to be made in order to obtain the necessary productions and conditions for the purpose in view. A special drawing (Fig. 23) has been prepared, showing at a glance the arrangement of wheels and parts that constitute the chief features of the frame. Whilst mentioning that the machine represented is the method adopted by a leading firm of machine makers, Dobson and Barlow, it is almost unnecessary to point out that other makers' designs vary so little from it that readers can very readily adapt the following calculations to suit the gearing of the machines with which they are directly in touch.

The driving pulley shown on the outside of the frame end receives its motion from a line shaft above. The size of this driving pulley, of course, varies according to the speed required and pulley on the line shaft, but under ordinary conditions an 18 in. × 13 in. will be found a good standard to adopt, although 21 in. is frequently used. On the driving shaft, just inside the framing, is keyed the inside driving pulley B, or, as it is sometimes called, the bottom shaft pulley. In different makes of machines this pulley varies, but for our present purpose 16 in. will be taken as its diameter; it drives, by means of a belt, a pulley C on the front roller, whose diameter as shown is 12 in. From this point the driving of the whole frame takes place, and it is here where the machine is stopped and started,

[1] Full calculations and drawings of the chief machine-makers' draw-frames are given in the author's book *Cotton Spinning Calculations.*

a fast and loose pulley being used for that purpose. The

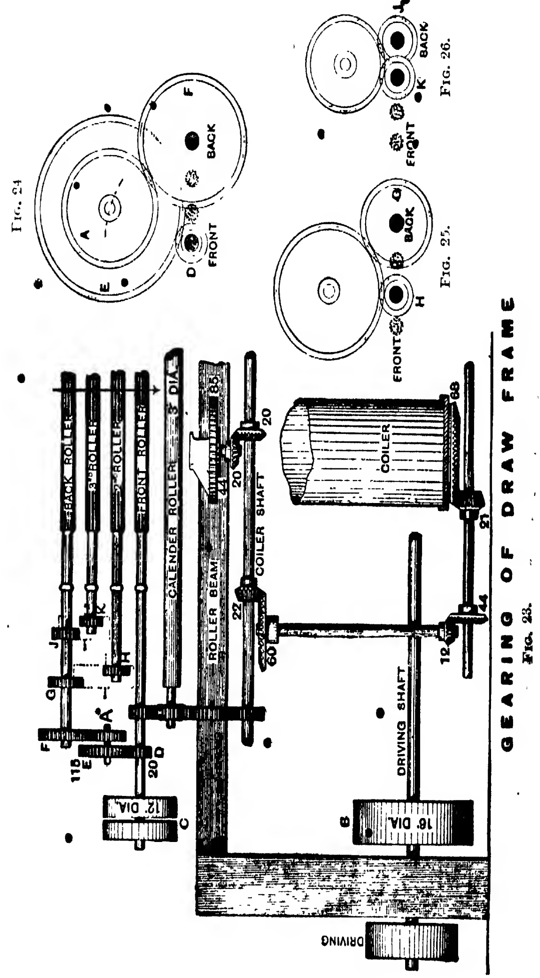


Fig. 24.

Fig. 25.

Fig. 26.

GEARING OF DRAW FRAME

Fig. 23.

front roller receives its motion direct from here, the other portion of the draw-frame receiving motion through the

gearing as represented in the sketch. The front roller drives the back roller, through D, a compound carrier A E, and the wheel F; the second roller is driven from the back roller through the wheels G and H, a single carrier coming between them to preserve the direction of revolution; the back roller also drives the third roller by the wheels J and K, a carrier again being necessary here to turn the roller in the right direction. The system shown is the one generally adopted now, but in some makes of machines the two intermediate rollers will be found driven at the other end of the frame, ostensibly with the object of reducing any tendency to twisting, or at least of neutralising it somewhat; but this is too palpable a fallacy to need explanation, and in all the best or newest designed machines the arrangement shown in the drawing is adopted. The calender rollers are driven from the front roller by a train of wheels whose continuation also drives the top coiler shaft. This shaft, through pairs of bevel wheels, drives each coiler top, whilst it is also the means of conveying motion through bevels to the bottom coiler shaft, from which the coiler can itself is turned. Elevations of the roller gearing are given in Figs. 24, 25, and 26, by which their disposition is clearly shown. To facilitate making the calculation, and putting to a practical test the rules that are given, the following table of particulars is presented:—

A	Draft wheel	Various, 40 to 90 teeth.
B	Inside driving pulley	Various dias., say 14 in.
C	Front roller pulley	12 in. dia.
D	Front roller wheel	20 teeth.
E	Crown wheel on top carrier	115 ,,
F	Back roller wheel	Various, say 80 ,,
G	Back roller wheel driving second roller	,, 45 ,,
H	Second roller wheel	,, 20 ,,
J	Back roller wheel driving third roller	,, 26 ,,
K	Third roller wheel	,, [illegible] ,,
Diameter of front roller		$1\frac{1}{2}$ in.
,, second roller		$1\frac{1}{4}$,,

Diameter of third roller	$1\frac{1}{2}$ in.
,, fourth roller	$1\frac{1}{2}$,,
No. of slivers per delivery	8 ,,
Speed of front roller per minute	264 revs.

Obtaining the correct draft is the most important calculation of the draw-frame, and this is done in the usual way by finding the surface speed of the rollers and dividing the slowest into the quickest, which gives a ratio or number that represents the draft. The front roller has the quickest speed, whilst the back roller runs the slowest, so if we find their respective surface speeds the question becomes an easy one.

(1) Draft between front and back rollers $= \dfrac{E \times F \times \text{dia. of front roller}}{D \times A \times \text{dia. of back roller}}$

$$= \frac{115 \times 80 \times 1\frac{1}{2}}{20 \times 58 \times 1\frac{1}{2}} = 7 \cdot 93.$$

It will be seen that this formula is made by simply considering the back roller as the driver and working back to the front roller. In most cases this is the best plan to adopt.

When the draft is already given or supposed, and it is required to find the necessary wheel, the same rule is applicable by substituting the required draft in place of the wheel A, as this is the change place.

(2) Change or draft wheel $A = \dfrac{F \times E \times \text{dia. of front roller}}{\text{Draft} \times D \times \text{dia. of back roller}}$

$$= \frac{80 \times 115 \times 1\frac{1}{2}\text{ in.}}{8 \times 20 \times 1\frac{1}{2}\text{ in.}} = 57 \cdot 5 \text{ teeth.}$$

For this result we take the next highest wheel, viz. 58 teeth. In order to save repetition of the above calculation, finding the "constant number" is advisable. This is done by using the above rule, but leaving out the draft, or, in No. 1, by leaving out the draft wheel.

(3) Constant number $= \dfrac{F \times E \times \text{dia. of front roller}}{D \times \text{dia. of back roller}}$.

$$= \frac{80 \times 115 \times 1\frac{1}{2}\text{ in.}}{20 \times 1\frac{1}{2}\text{ in.}} = 460.$$

From this constant number we can obtain either the draft or the draft wheel as follows:—

(4) $$\text{Draft} = \frac{\text{Constant number}}{\text{Draft wheel}}.$$

(5) $$\text{Draft wheel} = \frac{\text{Constant number}}{\text{Draft}}.$$

(6) Draft between first and second rollers
$$= \frac{\text{H} \times \text{F} \times \text{E} \times \text{dia. of front roller}}{\text{G} \times \text{A} \times \text{D} \times \text{dia. of second roller}} = \frac{20 \times 80 \times 115 \times 1{\cdot}5 \text{ in.}}{45 \times 58 \times 20 \times 1{\cdot}25 \text{ in.}} = 4{\cdot}23.$$

(7) Draft between the second and back
$$= \frac{\text{G} \times \text{dia. of second roller}}{\text{H} \times \text{dia. of back roller}} = \frac{45 \times 1\tfrac{1}{4} \text{ in.}}{20 \times 1\tfrac{1}{2} \text{ in.}} = 1{\cdot}87.$$

(8) Draft between the third and back
$$= \frac{\text{J} \times \text{dia. of third roller}}{\text{K} \times \text{dia. of back roller}} = \frac{26 \times 1\tfrac{1}{2} \text{ in.}}{21 \times 1\tfrac{1}{2} \text{ in.}} = 1{\cdot}238.$$

(9) Draft between the second and third rollers
$$= \frac{\text{K} \times \text{G} \times \text{dia. of second roller}}{\text{J} \times \text{H} \times \text{dia. of third roller}} = \frac{21 \times 45 \times 1\tfrac{1}{4} \text{ in.}}{26 \times 20 \times 1\tfrac{1}{2} \text{ in.}} = 1{\cdot}56.$$

(10) Production in 10 hours is found as follows:—
$$\frac{\text{Min. in 10 hrs.} \times \text{revs. of F.R.} \times \text{circumference of F.R.} \times \text{grains per yard of sliver}}{36 \text{ in.} \times 7000 \text{ grains}}.$$

(11) The "constant" number for production may be obtained for any diameter of front roller by using rule No. 10, but leaving out the grains per yard of sliver. When this is done the production is found as follows:—Constant number × grains per yard of sliver = production.

(12) $$\text{Weight of drawing} = \frac{\text{number of ends} \times \text{weight of carding}}{\text{draft}}.$$

(13) The draft can be found by the following rule:—
$$\frac{\text{number of ends put up} \times \text{weight of carding}}{\text{weight of drawing}}.$$

(14) The draft wheel can also be found by the proportionate method:—
$$\text{Draft wheel} = \frac{\text{required weight} \times \text{draft wheel on}}{\text{present weight}}.$$

(15) $$\text{Draft wheel} = \frac{\text{present hank} \times \text{draft wheel on}}{\text{required hank}}.$$

(16) The draft between the first and second × draft between the second and third × the draft between the third and fourth = total draft of the machine.

The horse-power required for driving the draw-frame is generally put down as 1 i.h.p. for 12 deliveries.

Draft.—On referring to rule (1) on page 41, it will be noticed that, although we are asked to consider the back

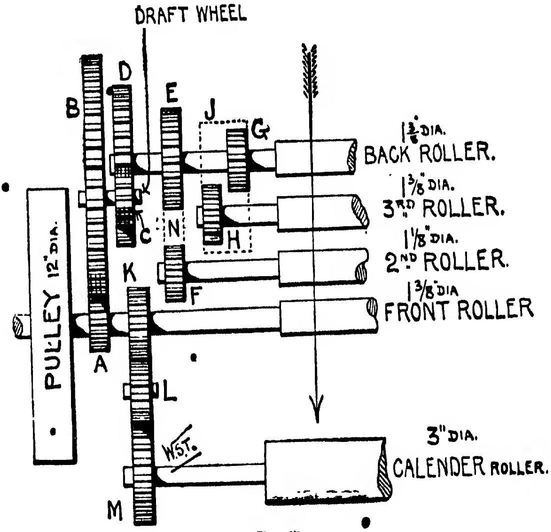


Fig. 27.

roller as the driver, we place the back roller among the driven wheels and the front roller among the drivers. This is puzzling to the student, so an attempt will be made to explain it.

Consider the gearing of Brooks and Doxey's draw-frame in Fig. 27, having the following particulars:—

Wheel	A	20 T.	drives	B 100 T.	Wheels N, J, and L are carriers and are not used in the calculations.
,,	C	40/70 T.	,,	D 70 T.	
,,	E	43 T.	,,	F 16 T.	
,,	G	22 T.	,,	H 18 T.	
,,	K	22 T.	,,	M 48 T.	

The diameters of the rollers are stated on the drawing. Since draft simply means dividing the surface speed of one roller into the surface speed of another roller, we must find the surface speed of the front roller and divide it by the surface speed of the back roller.

Now suppose the front roller has 200 revs. per min., its surface speed will be

$$350 \times 1\tfrac{3}{8} \times \tfrac{22}{7} = \frac{350 \times 11 \times 22}{8 \times 7} = 1512 \text{ inches per min.}$$

The surface speed of the back roller will be

$$\frac{350 \times A \times C \times \text{circ. of B.R.}}{B \times D} = \frac{350 \times 20 \times 58 \times 1\tfrac{3}{8} \times \tfrac{22}{7}}{100 \times 70}$$

$$= \frac{350 \times 20 \times 58 \times 11 \times 22}{100 \times 70} = 250 \text{ inches per min.}$$

$$\frac{\text{Surface speed of F.R.}}{\text{Surface speed of B.R.}} = \text{Draft}$$

$$= \frac{1512}{250} = 6{\cdot}04 \text{ total draft.}$$

We see from this that if we start our draft calculation from the back roller the front roller diameter must be on the top line and the back roller below. If we simply combine the two calculations into one we do so as follows:—

$$350 \times 1\tfrac{3}{8} \times \tfrac{22}{7} \div \frac{350 \times 20 \times 58 \times 1\tfrac{3}{8} \times \tfrac{22}{7}}{100 \times 70}$$

$$= \frac{350 \times 11 \times 22}{8 \times 7} \div \frac{350 \times 20 \times 58 \times 11 \times 22}{100 \times 70 \times 8 \times 7}$$

$$= \frac{350 \times 11 \times 22 \times 100 \times 70 \times 8 \times 7}{8 \times 7 \times 350 \times 20 \times 58 \times 11 \times 22}$$

$$= \frac{50 \times 7}{58} = 6{\cdot}03 \text{ total draft.}$$

If, in this last calculation, letters are used instead of figures, and using only the diameters of the rollers, we obtain—

$$\text{Dia. of F.R.} \div \frac{A \times C \times \text{dia. of B.R.}}{B \times D} = \text{Draft}$$

$$= \frac{\text{Dia. of F.R.} \times B \times D}{\text{Dia. of B.R.} \times A \times C} = \text{Draft.}$$

It will thus be seen that a simple form of reasoning easily explains why the front and back roller diameters occupy the positions they do in rules for draft. The driving of the rollers of the draw-frame is not always the same. Several systems are adopted by machine-makers.

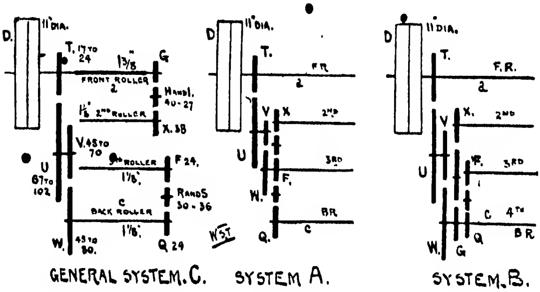


FIG. 28.

For instance, Howard and Bullough's have the three systems shown in Fig. 28. The calculations for these systems all follow on the same lines as the examples already given, so it is unnecessary to work them out here.

PRODUCTION OF DRAW FRAME.

Dia. of F.R.	Hours worked by frame out of 56½.	Revs. of F.R. per minute.	Weight of sliver per yd. in grains.	Hank of sliver.	Lbs. per delivery in 56½ hrs.	Lbs. per delivery in 10 hrs.	Nos of yarn and kind of cotton.
1⅛	46	400	66	·126	1020	180·5	10s to 20s China or Indian.
1⅛	46	400	60	·138	928	164·2	
1¼	46	350	60	·138	897	158·7	20s to 24s Indian or American.
1¼	46	350	54	·154	807	142·8	24s to 32s American.
1¼	46	350	48	·173	717	126·9	32s to 40s American.
1⅜	46	300	48	·173	679	120·2	32s to 40s American or Low Egyptian.
1⅜	46	300	44	·189	623	110·2	
1⅜	46	300	40	·208	565	100	
1½	46	280	48	·173	692	122·4	30s to 40s Egyptian.
1½	46	280	44	·189	634	112·2	40s to 45s ,,
1½	46	280	40	·208	577	102·1	45s to 50s ,,
1½	46	250	40	·208	515	91·1	60s ,,
1½	46	250	36	·231	463	81·9	70s ,,
1½	46	200	40	·208	411	72·7	80s ,,
1½	46	200	36	·231	370	65·5	90s ,,
1½	46	200	30	·277	308	64·5	100s ,,

The following table may also be a guide for production in American cotton :—

Dia. of roller	1⅜	1⅜	1⅜	1⅜
Speed of roller	320	350	380	400
Hank of card sliver	·15	·15	·15	·15
Draft	6	6	6	6
Production in lbs. per finished delivery	865	980	1030	1080

CHAPTER II

COMBING

Object of Combing.—It is advisable, now that the subject of combing has been reached, to explain clearly the position this process occupies in the cotton-spinning industry, and also to give the reasons why the treatment of the operation has been placed after drawing instead of after carding, which is the plan usually adopted by textile writers. The explanation necessitates a consideration of several important matters, a knowledge of which is almost essential in order to gain a clear understanding of much that will follow.

In the first place, it must be thoroughly realised that, although cotton spinning has the one great aim of bringing an irregular mass of cotton fibres into comparative order, and making them into a strong round thread, there is such a wide variation in the condition of the raw material, and also such a great range in its ultimate product, that the industry is, as a consequence, split up into several branches; and these—principally for economic reasons, as well as structural details of machinery conducing to variation of result—might also be termed distinct processes. Four branches or departments may be enumerated, viz. waste spinning, spinning low numbers, medium numbers, and high

numbers. Waste spinning we are not concerned abou but the other three are part of our subject. The variatio of the raw material used for either of these three purpos compels an almost corresponding variation in details structure, in type of machine, and in the arrangement the order or extent of the various processes. To make th clear, a list of machines in their order is given for spinnin from low numbers up to high numbers, and it will be see how the conditions vary as the better classes of cotton ar used.[1]

NOS. 3 to 10

1. Double vertical opener.	6. Drawing frame.
2. Single scutcher.	7. Slubbing frame.
3. Single scutcher.	8. Roving frame.
4. Single scutcher.	9. Mule or ring frame.
5. Carding engine.	

NOS. 10 to 20 : INDIAN COTTON

1. Double vertical opener.	6. Draw-frame.
2. Single scutcher.	7. Slubbing frame.
3. Single scutcher.	8. Intermediate frame.
4. Single scutcher.	9. Roving frame.
5. Carding engine.	10. Mule or ring frame.

NOS. 20 to 50 : AMERICAN COTTON

1. Single vertical opener.	6. Draw-frame.
2. Single scutcher.	7. Slubbing frame.
3. Single scutcher.	8. Intermediate frame.
4. Single scutcher.	9. Roving frame.
5. Carding engine.	10. Mule or ring frame.

NOS. 40 to 100 : EGYPTIAN COTTON

1. Double opener, with lap part.	5. Slubbing frame.
2. Single scutcher.	6. Intermediate frame.
3. Carding engine.	7. Roving frame.
4. Draw-frame.	8. Mule.

NOS. 80 to 100 : EGYPTIAN (double-carded)

1. Double opener, with lap part.	6. Draw-frame.
2. Single scutcher.	7. Slubbing frame.
3. Breaker card.	8. Intermediate frame.
4. Lap machine or Derby doubler.	9. Jack-frame.
5. Finisher card.	10. Mule.

[1] Very full details of these systems are given in Vol. III.

No. 100 upwards: Sea Island Cotton

1. Single opener, with lap part.
2. Single scutcher.
3. Carding engine.
4. Drawing before combing.
5. Sliver lap machine.
6. Ribbon lap machine.
7. Comber.
8. Draw-frame.
9. Slubbing frame.
10. Intermediate frame.
11. Roving frame.
12. Jack-frame.
13. Mule.

It will be noticed in the above lists that a more delicate treatment is afforded to the better-class cottons, whilst at the same time the operation is lengthened in order to obtain a greater regularity of yarn. When we come to the highest numbers a new process is introduced called combing, closely following a preliminary course of drawing. It will be seen therefore that, throughout, the operation of drawing always follows that of the card.

The above lists show that combing is a process which is only introduced into the spinning of high numbers or counts of very good quality. As its name implies, it is primarily a combing operation—that is, every fibre of cotton is practically isolated and straightened out, in which condition it is maintained afterwards by the contiguity of the surrounding fibres. The mechanical method of performing this action introduces of necessity several of the most important effects that make combed yarns possible, and gives to them the qualities that make them so valuable for the special purposes they serve.

In the notice with which the chapter on carding was prefaced,[1] attention was called to the condition of the cotton, which rendered that process an indispensable one in the manufacture of yarns, and those remarks are doubly applicable to the subject we were now considering; but, in addition, there are several important properties that combed yarns must possess, which are practically unattainable by

[1] See Vol. I.

the use of the card alone. These properties may be summarised as follows:—First, the fibres composing the yarn must be uniform in length. From the description of the card, we are prepared to acknowledge that this result is impossible of attainment with the most perfect card of the present day, although it approaches much nearer to such a state than machines of a former period. An examination of a sliver will show beyond doubt that large quantities of irregularly stapled cotton exist, and it is to eliminate the shorter fibres that we have recourse to combing. Secondly, each fibre must be combed out as straight as possible, and must be maintained in this position. We saw that this combing action was performed very effectually by the card, but in that machine the perfect freedom of the fibres gave them full liberty to return to their naturally curly state because of the elasticity they possess. In combing, the large numbers of adjacent fibres mutually prevent this, and consequently we get the fibres laid side by side in a very level condition. Thirdly, we must have the fibres incorporated together in some kind of order. They must overlap each other in such a way as to exclude any possibility of chance in their arrangement, and so that thorough reliance can be placed upon the strength that such an arrangement gives. In the card it was seen that the fibres were massed together in a haphazard fashion, without order or regularity so far as local conditions were concerned, and we can easily see that the binding of the fibres into a strand of sliver depended on no fixed method in their distribution, and to that extent there is a palpable weakness. In the comber we have a machine that renders these objects easy of accomplishment, but the combination of mechanism that is employed in attaining this successful result has given us a machine that may be considered one of the most complicated

and ingenious of the many that are used in the cotton-spinning industry.

Before combing can be resorted to, the sliver from the card must be thoroughly prepared for what is necessarily a very delicate operation. In the first place, the arrangement of the fibres in the card sliver is (as already pointed out) of such a nature that the needles of the comber would be considerably damaged if an attempt were made to comb them in this state; and, secondly, the great irregularity of the sliver would be reproduced in the comber, and at the same time cause very unequal work to be thrown on the various organs of that machine, with a corresponding waste of good fibres. These difficulties are avoided by first passing the card slivers through a draw-frame, with the result that the fibres are partially parallelised and made more regular length for length.

In doing this, another consideration must be taken into account. When the cotton is passed through the comber, it is combed out by a series of very fine steel needles, each row having a width of from 7 to 11 in. This introduces the necessity of forming the slivers into a lap, so that a number of them lie side by side, making up the required width. The slivers are therefore taken from the draw-frame, and passed through a machine called a **sliver-lap machine.** This lap is very compactly made on a wooden core, and is about 9 to 12 in. in diameter. The cans are placed behind the machine, in number from 14 to 20, according to the size of lap desired, and the slivers guided through two or three pairs of small rollers having a slight draft. From these it passes forward between one or two pairs of calender rollers, whose object is to consolidate the lap and form a kind of fleece of the combined sliver. On emerging from these rollers it is wound on the wooden core, whose revolu-

tion is obtained by the friction produced by its resting upon large revolving bowls. The selvedge is kept perfectly free from damage by circular end-plates, which revolve with the lap, and in this way friction of the lap ends with the framing of the machine is avoided. A stop motion is an absolute necessity in a machine of this description, and in all makes of it the slivers are first passed over spoons or some other system of stopping the machine, so that directly an end breaks or a can runs empty it instantly stops.

The small draft alluded to above varies slightly, but it ought never to exceed two.

The power required for driving is usually put down as ½ i.h.p., and its production under ordinary conditions is 450 to 500 lbs. per day.

The speed of the driving pulley on the machine varies greatly in different makers' machines, but this depends very much on the arrangement of the gearing. One large firm, who have a speciality in this machine, advocates 200 revolutions, whilst another gives a speed of 120 revolutions per minute.

The remark ought to be made here that the principle of the machine just described is also the same for the Derby doubler, with which it is often confounded.

The Derby doubler varies from the lap machine principally in the method of feeding the slivers. A long V table is used, the point being farthest away from the machine, and the cans are arranged on each side. This allows a much larger number of slivers to be used (22 to 60), and also gives a greater width of lap (10 in. to 37 in.). It was formerly extensively employed in making the laps for double carding, and is now chiefly used for the card in spinning waste and low numbers. The sliver-lap machine has, at present, almost entirely taken its place for other purposes.

In a large number of cases the lap is now taken to the comber, but before considering its treatment there, it will be interesting to notice another system which is becoming more generally adopted in the preparing of fine yarns.

The fleece taken from the sliver-lap machine, when held up to the light, is seen to consist of thick and thin places running in the direction of the length. This, of course, is caused through the slivers not being incorporated with each other, simply lying side by side, the outer fibres of each attaching themselves to those of the one next to it. This condition is unavoidable in the previous machine, and as it is not a desirable state of things, a remedy is sought in the following manner:—The slivers are taken direct from the card, and passed through the sliver-lap machine. The lap thus formed is taken to a **ribbon-lap machine and draw-frame combined.** The laps put up vary in number, but are generally six. The fleece from each is passed through four lines of rollers arranged on a similar plan to those of the draw-frame. Here they are submitted to a draft—in this case six—and they emerge attenuated to this extent. They are now carefully guided along specially curved plates, which bring them down on to a smooth table, upon which they are drawn lengthwise of the machine to its end. Each fleece in passing forward is brought under the other fleeces, as they are guided in a similar way, and by the time they reach the end of the machine they are all superimposed, and a combined lap is the result, with the irregularities reduced to an extent that shows little, if any, variation of light and shade when held up to the light. The combined lap is now passed through a series of calender rollers, which effectually consolidates them, and neutralises any tendency to licking.

A good idea of this machine, as made by Dobson and Barlow, can be obtained by an examination of the four illustrations, Figs. 28A, 28B, 28C, and 28D. It will be noted that Figs. 28A and 28B give the full gearing plan of the machine, the driving end when standing in front of the machine is shown in Fig. 28B, whilst the lap end is given in Fig. 28A. Elevations of the machine are represented in Figs. 28C and 28D. Absolute smoothness of the curved plates and table is necessary, and frequently these are nickel-plated and highly polished. The drawings are sufficiently clear and detailed as to render a further description unnecessary.

Draw and Lap Machine.

(Reference to Illustration).

A Draft wheel.
B Driving pulley.
C Front roller driving wheel, 65 to 78 teeth.
D Front roller wheel, 65 to 78 teeth.
E Front roller wheel driving F.
F Chased boss carrier.
G Back roller wheel.
H Back roller wheel driving second roller through 70ˢ carrier.
J Second roller wheel.
K Back roller wheel driving third roller through 52ˢ carrier.
L Third roller wheel.
M 3″ dia. calender roller driving wheel.
N 3″ dia. calender shaft wheel.
O Lap end driving bevel.
P Cross shaft bevel.
Q 6″ calender roller driving wheel.
R 6″ calender roller wheels.
S Lap drum driving wheels.
T Back lap drum wheel.
U Back lap drum wheel driving front drum wheel.
V Front lap drum wheel.
W Change wheel for draft between wood lap roller and back roller, 37 to 62 teeth.

Another example of the ribbon lap machine as made by John Hetherington and Sons is presented in Fig. 28E; it will be found a simple matter to work out the calculations from the gearing shown.

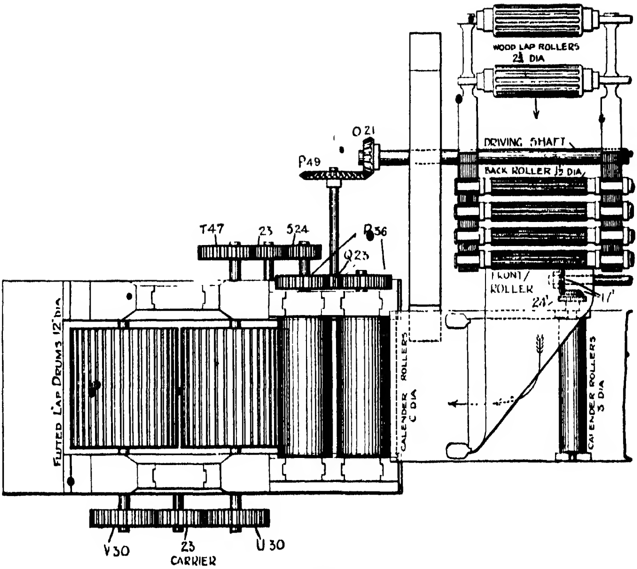


Fig. 28A.

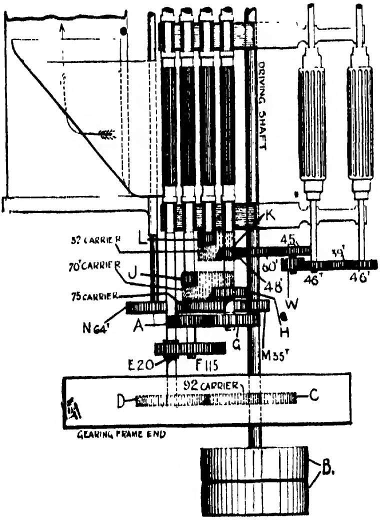


Fig. 28B.

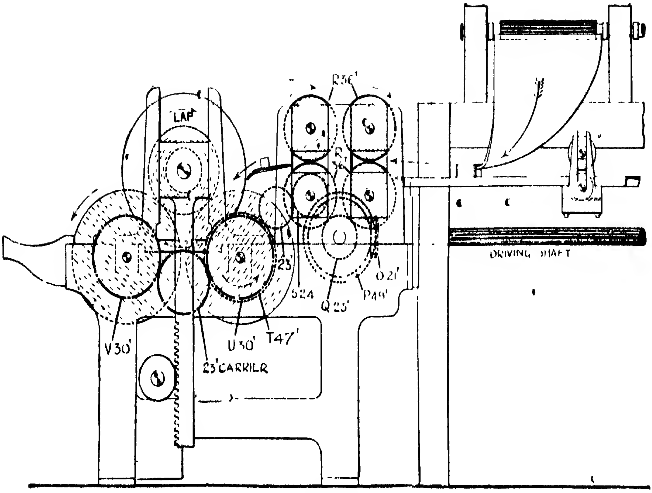


FIG. 28C.

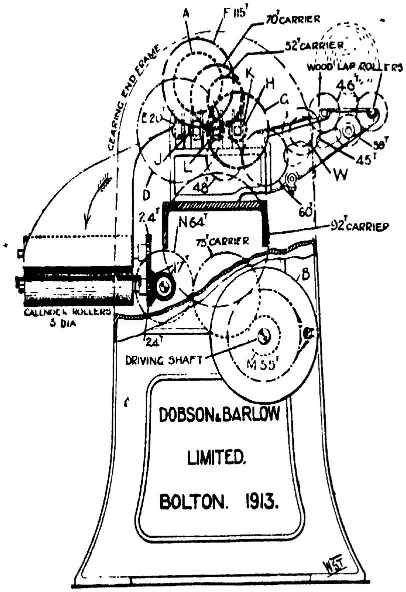
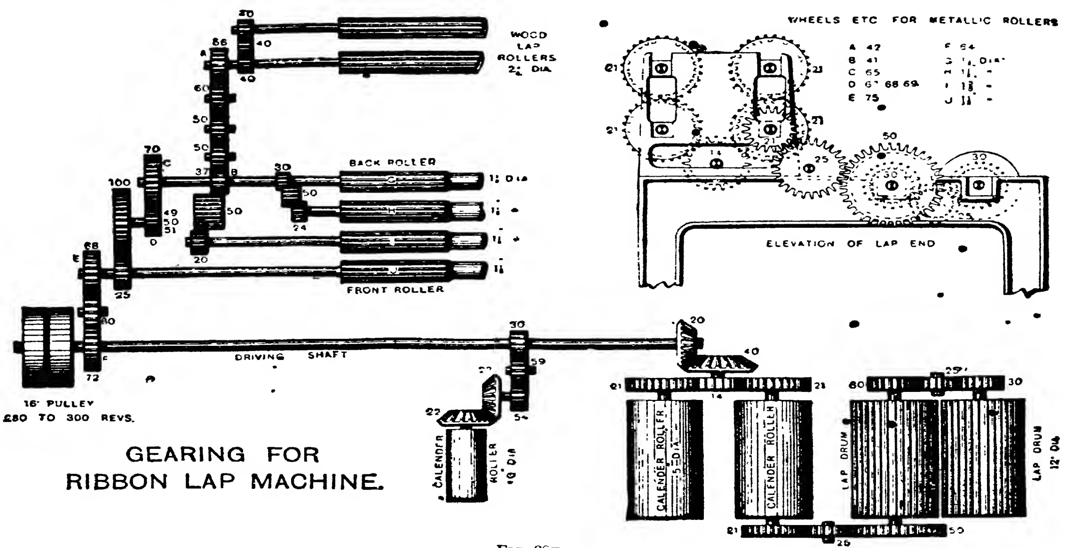


FIG. 28D.



GEARING FOR RIBBON LAP MACHINE.

FIG. 28E.

Less waste is made in the comber than would otherwise be the case, and the combing process is rendered easier by the uniform thickness and equally distributed arrangement of the fibres in the lap which is fed to it.

One horse-power is required to drive the machine, and its production is equal to about 450 to 500 lbs. per day, this varying with the class of cotton used. Its driving pulley speed is usually 260 revolutions per minute.

For the very best yarn it is sometimes considered advisable to comb the cotton twice over. When this is done, the method generally adopted is as follows:—

When a ribbon-lap machine is used, the cotton is passed through the following machines in their order:—

1. Sliver-lap machine.	4. Sliver-lap machine.
2. Ribbon-lap machine.	5. Ribbon-lap machine.
3. Comber.	6. Comber.

If double combing is resorted to without the ribbon lapper, the order of the machines is as follows:—

1. Draw-frame.	4. Draw-frame.
2. Sliver-lap machine.	5. Sliver-lap machine.
3. Comber.	6. Comber.

In double combing, a system is sometimes adopted as follows:—

1. Sliver-lap machine.	3. Sliver-lap machine.
2. Comber.	4 Comber.

Description of the Comber.—We now come to deal with the combing machine itself. In the first place, a brief description as to its methods of working will be advantageous, as it will then enable a better grasp to be obtained of the various operations, when describing its mechanical movements, which effect the result.

The lap is taken from the ribbon-lap machine or the

sliver-lap machine, and placed on corrugated wooden rollers behind the comber. The machine is divided up into several sections called heads, six or eight being the usual number. Each head takes a lap, and is complete within itself, except that the driving arrangement of the complete machine is placed at one end. The lap is passed through the feed rollers intermittently, a short length at a time, this length depending upon the staple of the cotton being treated. In passing through it comes between two plates called nippers, and here it is held whilst a revolving cylinder partially covered with rows of needle combs passes through it, its needles combing out all the short and neppy fibres during the revolution. Directly this is done, a fluted portion of the cylinder comes under the combed cotton, and at the same time a movable roller is allowed to drop upon it, and as the revolution continues the combed cotton is carried away and overlapped by a backward motion of a fixed detaching roller upon the lap that has previously gone forward. Just as this is being done, another comb is brought down, and lies in the path of the cotton as it passes onwards. The finished sliver is conducted to calender rollers, which carry it forward. The various actions are repeated at a rapid rate, and a continuous fleece of combed cotton is delivered into coiler cans at the end of the machine.

In order that the above-mentioned actions may be better understood and illustrated, a section through the principal features of a machine is shown in Fig. 29. Although the drawing represents a double form of comber, it will be seen, as the description is given, that it differs very slightly from the single machine, the difference being in the cylinder, which contains only one set of combs and one fluted portion. (Compare Fig. 31.)

The lap is placed in position upon the wooden rollers, whose revolution unfolds it and feeds the sheet of cotton down a highly polished plate in the direction of the arrow.

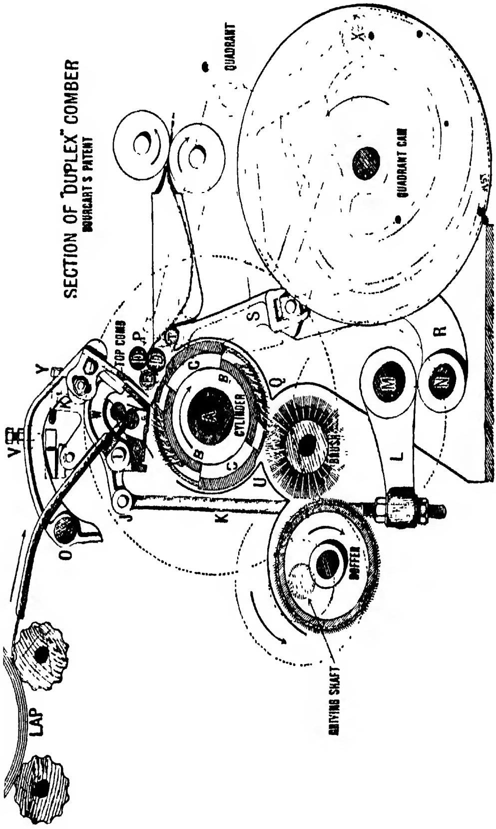


FIG. 29.

The feed rollers F F carry it forward intermittently, the exact amount of the feed being regulated according to the staple of the cotton. The length fed goes forward between the nipper H and a cushion plate G. When sufficient has

passed through the cushion plate, H descends and presses against the cushion G, thus holding the cotton very firmly. At the same time the needles B of the revolving cylinder come round into contact with the portion of the lap projecting from the nipper, and, in passing through it, thoroughly free it from its short fibres and impurities left in by the previous processes. Immediately the combs have finished their work, the rollers D D are actuated so as to turn back a short portion of the cotton that they took forward at the preceding operation, and just as this is done the fluted portion C of the revolving cylinder has moved so that the leather detaching roller E can be brought into contact with it. This leather-covered roller, driven through friction by the fluted detaching roller D, with which it is pressed into contact by springs or weights, directly it touches the fluted segment C, takes the combed cotton forward. Simultaneously with this motion, the top comb comes down right in the path of the cotton, and so the fleece, in passing through it, is cleared of any short fibres that may have been held by the nipper. It will be seen that this action completely separates the combed portion of the cotton from the rest, and consequently a piecing must be effected. This is done by causing the fluted detaching roller D to return a portion of the combed cotton it has taken forward, and, whilst the cotton is being drawn through the top comb, the roller E overlaps a portion of its delivered cotton upon that part that has been returned by roller D, and in this way a piecing is brought about.

The forward and backward motions are obtained in the following manner:—A pinion P rides loose upon the end portion of the detaching roller D. The motion that P receives is transmitted to D through a clutch wheel, which is actuated by means of a cam. Gearing into P is the

quadrant shown in dotted lines, one end of which carries a bowl X, which receives its motion from the quadrant cam. This cam is formed so that it will cause the detaching roller D to turn backwards a given length and immediately turn forward a greater distance, a portion of which is used for piecing purposes.

When this is done, the rollers D and E are at rest whilst the combing process is going on, and so the quadrant cam has a portion of its revolution idle so far as the quadrant is concerned, the clutch wheel at the same time being out of gear. When the combing process is finished, the clutch is put into gear, and the cam, acting on the quadrant, repeats the operations of backward and forward motions. The leather detaching roller E is put into and taken out of contact with the fluted segment C by means of the lever S centred at T. This is actuated through the lever R by the roller cam.

The top comb is centred at O, and its setting is effected through the set screw at V.

The nipper H, centred at I, receives its motion through the lever L, and the rod K from the nipper cam, its movement being regulated by the cam on the one hand and by the setting screw Y on the other. The centre I is carried by a kind of cradle, upon which the cushion plate G is fixed. The cradle, being centred at W, allows the cushion plate to yield a little, and so be depressed quite close to the cylinder, when the nipper H presses against it. This enables the needles to effect a better combing, since the cotton is brought as near to them as possible.

The foregoing is only a brief description of the comber's action. An examination of its details and full explanations of its operations will follow.

When considering in detail the various movements of

the comber and their results, the broad fact must be kept in mind that the machine depends entirely upon an intermittent action of the several parts, and each operation is so dependent upon the other that the slightest variation from the correct time of acting destroys the efficacy of the machine, or neutralises to a considerable extent the objects for which it is used. These several operations may be summarised as follows:—The feed motion, in which the lap is fed to the cylinder to be combed; this is of necessity intermittent; the length that is fed is also dependent upon the staple being used. The nipper motion, for holding the cotton during the process of combing; it is intermittent in its action, and is arranged to allow the cotton to go forward after it has been acted upon by the cylinder. The actual combing operation follows next, by means of the rows of needles on the cylinder passing through the lap, after which the combed portion is taken on by the detaching roller. The backward and forward motion of the detaching roller; and, finally, the delivery of the finished material by calender rollers to the draw box and coiler. In addition to the above, there are several movements taking place either intermittently or continuously during the cycle of operations enumerated, but their dependence is so close on those given that it is not advisable to speak of them as distinct actions. Attention will first be given to the feed motion, and whilst the descriptions will be illustrated as fully as possible as the various details are dealt with, it is recommended that reference should be made to as many of the drawings as possible, in order to gain a clear idea of their relative positions and importance.

A drawing is given in Fig. 30 showing the method generally adopted for obtaining the intermittent action of

the feed rollers. A is the cylinder shaft, driven from the driving shaft by gearing through the large wheel B (see Fig. 29). On this wheel a disc plate C is fastened containing a pin D. A little distance from the axis of the cylinder is a stud carrying a star wheel E, into the teeth of which the pin D gears during a portion of a revolution

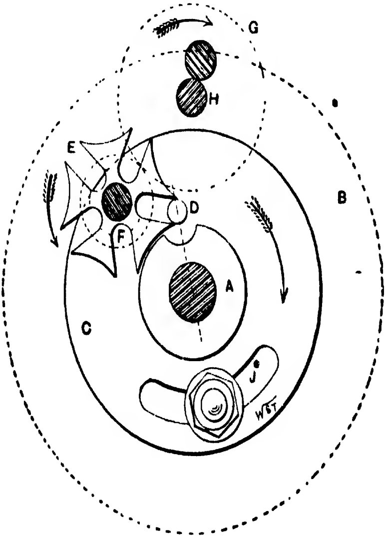


FIG. 30.

of the cylinder. The stud also carries a wheel F, whose pitch line is shown, and which works into a wheel G on the feed roller H. This arrangement contains all the requisites for the desired action, and the following description may be given as to its precise working. The cylinder is built up alternately of needles and a fluted surface—the needles for combing and the fluted surface for carrying the combed cotton away. Clearly the feed cotton must be

delivered to the cylinder just before the fluted segment comes forward; this permits the delivered cotton to be drawn forward when the leather detaching roller comes on the fluted segment. This introduces the necessity of some setting arrangement that will enable this delicate adjustment to be made; and so we find, as in the sketch (Fig. 30), that the pin D is attached to a movable disc C, which in its turn is connected to the wheel B by the screw J. In this way the engagement of the pin D with the star wheel E can be very carefully and exactly made so as to fall in with the correct portion of the cylinder's revolution. The star wheel itself is made with five teeth, as shown. The pin D can only act on it during part of a revolution The remainder of the time it is stopped and made immovable through the concave formation of its outer circumference being in contact with a circular portion of the boss on C. The connection of E with the feed roller by gearing is a necessity, because the machine must be capable of working various staples of cotton, and consequently there must be some facility for obtaining a variation of the length delivered by the feed roller H. This is readily obtained by the interchangeability of the wheel F with larger or smaller ones just as they are required. In this way the revolution of H can be regulated as to the amount it delivers to the cylinder.

The above arrangement is the one generally adopted for a single nip comber, but when a "duplex" or double action comber is made, it is clear the feed roller must deliver the required length of cotton twice during one revolution of the cylinder, because in such a case the cylinder has a double set of combs and two fluted segments, and for each set the feed rollers must deliver material. The necessary effect is obtained by using two of the pins

D in the disc C, one being placed diametrically opposite the other. In this way the star wheel is acted upon twice during a single revolution of the cylinder.

It will be understood that the intermittent action of the feed rollers must result in the same motion being given to the fluted wooden rollers upon which the lap rests when placed behind the machine. The requisite motion for doing this is transmitted by means of suitable gearing, which will be illustrated at a subsequent part of the description.

The next feature to demand attention is that part of the comber known as the "nipper." We have already seen that this is a combination of levers which are brought into play for the purpose of holding the cotton firmly, without injuring it, whilst the cylinder combs out the portion of the lap that protrudes. In explanation of this action a drawing is given in Fig. 31, to which reference will be made in the following description. The principal features shown are similar to those in Fig. 29, but in the present case a single combing cylinder is exhibited; to this the remarks will apply. A is the cylinder, whose fluted portion C has just made the piecing and carried forward the combed portion of the sliver. Directly this has happened, the feed rollers F F must deliver a sufficient length of the lap for the next combing operation, and at the same time the cushion plate G and the nipper knife H must open to allow this length to go forward. Immediately this is done, the nipper and cushion plate are brought together, and hold the cotton as the teeth of the cylinder pass through it. The details of this action will now be explained.

The method adopted for obtaining the opening and closing effect of the nipper is generally by means of a cam,

as shown at R; this cam is grooved in such a manner that, acting through a series of levers, it produces the necessary movements of the nipper. A shaft M goes the full length of the machine, and on it are placed a series of levers L, one being used for each head. These levers have connected to them short connecting rods K, the upper part of which is connected by the pin J to one end of the nipper arm, whose fulcrum is at I. On the shaft M a lever N is fixed, which carries a bowl P, working in the groove on the face of the nipper cam. When the bowl receives movement from the cam it gives a rocking motion to the shaft M, and this is transmitted by the levers L and connecting rods K to each nipper in the machine simultaneously: the cam is formed so that whilst revolving it keeps the nippers opened a sufficient length of time to allow the fed cotton to go forward. This action is shown taking place in the sketch, but as the cam continues its revolution, P will be moved a farther distance from the centre to P_1 until the point Q is under the shaft. When this occurs, it will be seen, the nipper is closed, and in this position it will remain as long as the bowl is working in the concentric part of the groove of the cam QRQ.

In connection with this intermittent action of the nipper, one or two considerations have compelled an arrangement of the levers to be made which is not so simple as the description just given would imply; therefore it will be well for the reader to closely follow the description. The cam, as already described, causes the nipper arm to turn round I as the fulcrum, but this is only a part of its action: for directly the nipper H touches the cushion plate G (the cotton, of course, between them) the plate is forced downwards. Now it will be noticed that G is carried by a frame or cradle which also carries the fulcrum I; this frame is

centred at $W_{,}$, and kept in position by a strong spring attached to a projection S and the framing of the machine. When, therefore, G is depressed by the pressure of H it

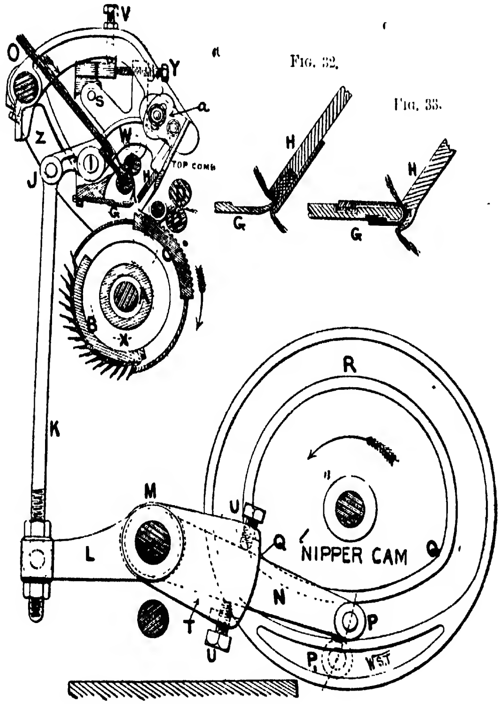


Fig. 32.

Fig. 33.

Fig. 31.

commences to move in a smaller arc of a circle, having W as its centre. This movement, it will be seen, brings G very close to the surface of the cylinder, and consequently enables the cotton to be combed very close to the nip. When the combing is finished the nipper begins to return to its original position; but it must clearly be seen and

understood that the cotton is not free from H and G until G occupies such a position that when the cotton is at liberty to be taken forward it is compelled to pass through the teeth of the top comb. This position is a very delicate one to adjust, and is regulated by means of the setting screw Y, which bears against a portion of the framing (shown by shaded lines in the drawing).

If some arrangement of this kind was not made, the cotton, after being combed, would lie in the teeth of the cylinder or on the surface of the fluted segment. In this position it would be impossible to pass it through the top comb, and as a consequence the combing operation would give only a portion of the good results that are now obtained from it. By allowing the cushion plate, whilst still holding the cotton, to be raised away from the cylinder, we raise the combed fibres into a position where they are obliged to pass through the top comb as they are taken forward by the roller E.

It was formerly the custom to place the nipper cam at one end of the machine, but the absolute exactness that was required by the simultaneous movement of each nipper was found to be slightly interfered with by the torsion that was produced in the shaft M. Strengthening the shaft was the first remedy tried, but ultimately the best arrangement was adopted of placing the cam in the middle of the comber, in which position it will be found in all the latest and best machines.

We have already spoken of the great degree of accuracy that must be maintained between each action. Every means is adopted to obtain this precision. It will readily be understood that the closing of the nippers and their opening at the right moment is a very important matter, so we find that adjusting arrangements are provided to

obtain the necessary regulation, as shown at U U and at the lower part of K, where it is connected by a swivel joint to the lever L. From these points the exact movement of H can be regulated. N in reality is a lever working loose on the shaft M, but is so arranged that by pressing against the screws U it moves the lever T, which is keyed on the shaft. This enables an adjustment to be made of a very delicate character when the cam is being set.

An enlarged view of two kinds of nippers is shown by Figs. 32 and 33. In Fig. 32, as made by Dobson and Barlow, the cushion plate G is made with a dull, thin edge, and this is pressed against a strip of leather inserted in the nipper H. A firm hold of the full width of the lap is obtained by this means, and whenever the leather requires renewing it is a simple matter to turn it round or replace it. The other illustration (Fig. 33) shows a well-known method of getting the same results, but it is not of so simple a character as the previous one, and the replacing of the leather is more difficult, and requires greater care.

The movement of the top comb is obtained in the following manner:—On cylinder shaft is fixed a cam X, shown in dotted lines, which, during a revolution, actuates a lever Z which rests upon it. This lever is fastened to the shaft O, to which is also fastened the top comb, so that the cam X, through the lever and the shaft, raises and lowers the comb as required. The comb's adjustment is obtained by means of the setting screw V, which rests upon a fixed portion of the machine. Several other adjustments can usually be made—for instance, the position of the top comb can be altered by the set screws at "a," a radial slot being provided to allow of this, and also the cushion plate G can receive a slight regulating through the set screw shown in the sketch. As a rule, small projections are fastened on

the cushion plate in order to direct the lap on to the cylinder, as well as to prevent bad selvedges forming.

The next motion that requires consideration is that known as the "roller motion," or, more correctly speaking, the detaching roller motion. A general idea of its action has already been given, but a reiteration of its main features will enable its functions to be better apprehended in the following explanation. After the combs of the cylinder have passed through it, the cotton is raised up out of contact with the teeth by the action of the cushion plate. Directly this happens, the combed portion must be pieced up to the cotton that was acted upon during the previous combing action, and which has been carried forward by the rollers D. To do this a part of the finished sliver must be returned so that the new portion will overlap it, after which the combined length will pass on to the coiler. To obtain this backward motion, and then a forward motion, to immediately follow it, has been the occasion for the display of much ingenuity. Two of the principal means employed for effecting it will be given at this stage. The first is called the quadrant motion, and is illustrated in Fig. 34. Reference will also be made to Fig. 29, which represents this motion in another position, and is suitably depicted to serve as an illustration to this part of the subject.

On the shaft F is fixed a cam called the "quadrant cam." Working in the groove on the face of this cam is a bowl X, carried by one end of a specially formed lever, whose centre is at B, and whose other end is formed as part of a wheel with teeth. From this feature it receives its name of quadrant. This toothed portion gears into a small wheel P, which rides loose upon the detaching roller D, but which, when occasion demands it, can be put into gear with a clutch wheel fastened on the detaching roller, and in this

way it gives motion to D. In the drawing (Fig. 34) the position of the cam is such that the wheel P is on the point of being reversed, or, in other words, receiving its backward motion. The amount turned back varies of course according

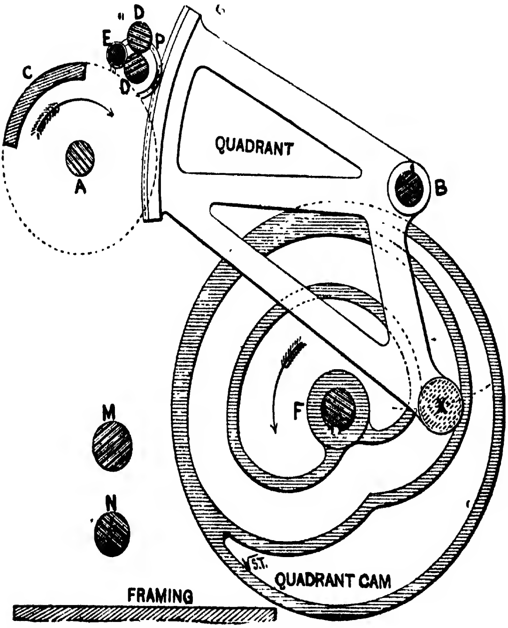


FIG. 34.

to the staple of the cotton being worked, but from $\frac{3}{8}$ in. to $\frac{5}{8}$ in. is usual. When the bowl X has approached the centre as near as the groove will allow, it immediately begins to move outwards again, and it will be noticed that this outward movement will result in the roller D taking the cotton forward, and as the groove of the cam extends further from the centre of the shaft than the point where

the backward motion begins, we can readily see that a longer length will be delivered forward than the amount returned. The difference between the two lengths will, of course, give us the total length of finished sliver the machine delivers per "nip," as it is termed.

A clearer understanding of this complicated action may be obtained by referring to Figs. 35 and 36. Here we have the cam detached from the rest of the machine, and a plan of the mechanism is also given, so that the two actions can be easily followed.

The black spots in the centre of the groove represent the position the centre of the bowl occupies as the cam revolves.

When the bowl is on the line A the backward motion is on the point of beginning, as we saw in Fig. 34. At the same time the wheel P (Fig. 36) must be put into gear with the clutch F, which is keyed on the detaching roller D, otherwise the roller will remain stationary. So at point B (Fig. 35) the clutch H must be set so that the clutch wheel P is put into gear. As the cam revolves, the line C will represent the lowest position the bowl X can attain, and thus the backward motion is finished, and is immediately followed by the forward motion. Usually, however, a very slight interval is allowed between the finish of the backward motion and the beginning of the forward part, so as to allow the leather detaching roller to be brought down on to the fluted portion of the cylinder, which has by this time been brought round, and occupies the position suitable for it. This interval is shown from C to D. Afterwards, onwards to F, the forward motion continues. When this point is reached, as is shown in Fig. 29, the bowl is working on a concentric part of the cam groove, and of course no further motion of the detaching roller can take place, and

in addition the clutch is brought out of gear at the same time. It takes a slight interval to do this, and the drawing represents it from G to H. Just before the forward motion is completed, it is necessary to move the leather detaching roller E (Fig. 34) from the flutes of the cylinder, so as to be clear of the teeth as they come forward. The point E represents that part of the cam occupied by the bowl when

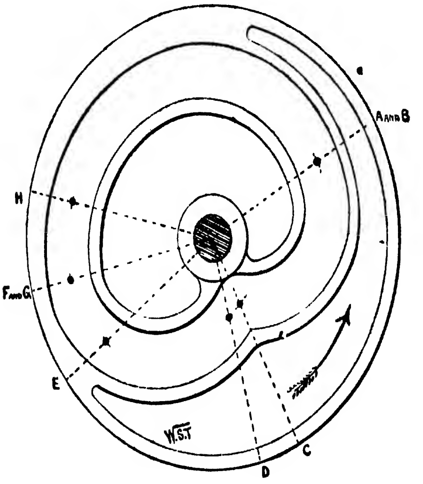


FIG. 35.

this is done. From H round to A again the cam is inoperative so far as moving the roller D is concerned, because the clutch is out of gear, and the movement of the quadrant is simply one of preparation for the next backward motion. The above description can be summarised, so far as regards the action of various parts of the cam, by the following table:—

REFERENCES TO FIG. 35

A Beginning of the backward motion.
B Beginning of the clutch going into gear.
C Finish of the backward motion, and beginning of the forward motion.
D The leather detaching roller touches the fluted segment of the cylinder.
E The leather detaching roller leaves the fluted segment of the cylinder.
F Finish of the forward motion.
G Beginning of the clutch coming out of gear.
H Finish of the clutch coming out of gear.

The above cycle of actions are practically the same

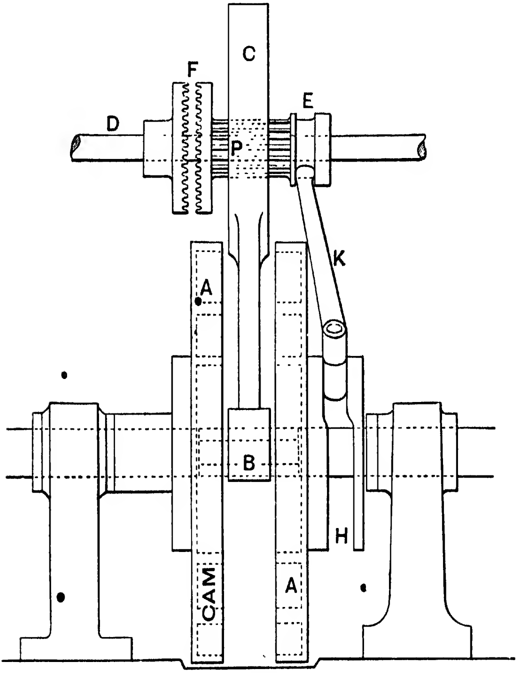


FIG. 36.

in a double form of comber, the only difference being that the cam revolves twice during one revolution of

the cylinder, and also that the curves and intervals are slightly different, owing to the flutes and combs not being proportioned on quite the same lines as in the single form.

Another method of actuating the detaching roller is by means of the notch wheel arrangement. This is the most general system of accomplishing the above purpose, and a drawing is given in Fig. 37 of its essential features, so that its action can be clearly understood. A is the cam shaft, on which is fastened the face cam B; working in the cam groove of B is a bowl C, carried by one end of a lever centred at D, and which is shown in the drawing in dotted section-lines; the other end of the lever carries a catch E, a projection on whose end fits in the notches cut on the periphery of a circular plate F, which also has D as its centre. It will be noticed that the projection on the catch E is square, and that the notches are also of the same shape, so that whichever way the catch moves the plate must follow. The catch is kept in position by the spring G. An examination of the drawing will show that the movement of the cam B will cause a backward and forward motion to be given to the bowl C, exactly in the same manner as explained in the previous method. The position occupied by the bowl in the sketch shows it to be on the point of commencing the backward movement. This effect is transmitted by the catch E to the notched plate F. On the same centre D as the plate is an internal wheel H, into which gears a small pinion J fastened on the detaching roller, so that any motion given to the notched plate will be given in a less degree to the detaching roller, according to the relative number of teeth in each wheel. Now, since the detaching roller is stationary except during the backward and forward motions, some means must be provided

of taking the catch out of gear with the notch wheel. This is provided for in the drawing by connecting to the catch a short lever carrying a bowl K, which rests upon the outer

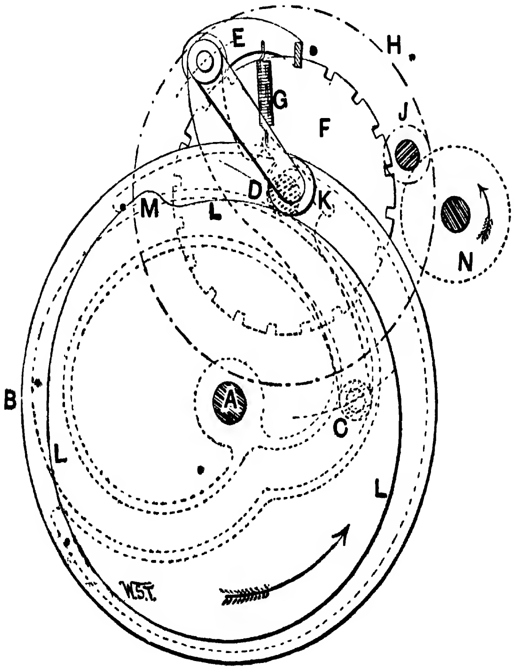


Fig. 37.

circumference of a cam plate L, fixed on the shaft A. So long as it is necessary for the catch E to engage with the notched wheel F, the form of the cam plate L is such as to have no effect on it, but when the forward motion is finished the catch must be taken out of gear, and so L is made with a curved projection M, which during its revolution comes under the bowl K and lifts the catch E out of the notch. The

necessary position of the projection M, so that the timing of the various actions is correct, can be readily made.

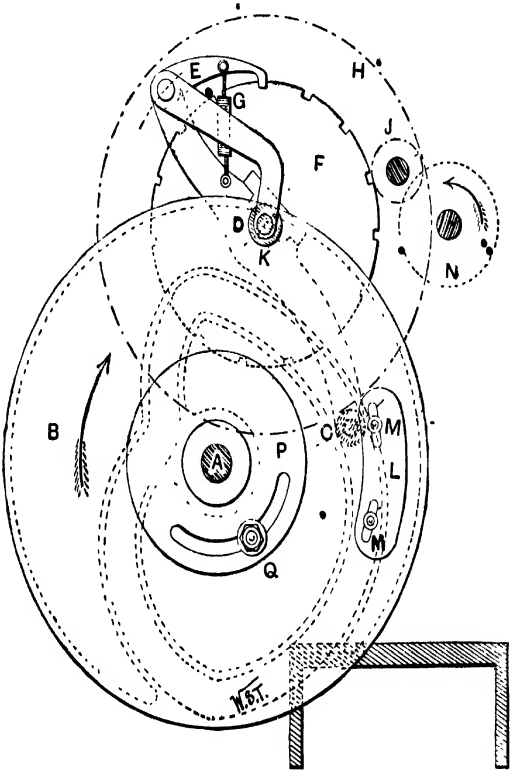


FIG. 38.

The cylinder is shown in dotted lines at N, and also the direction of its rotation.

In Fig. 38 we have an almost identical arrangement with the last one. A close inspection of the illustration will, however, disclose one or two details that are worth

observing. In the first place, the cams are a little different at the points where the changes are made. This is a detail which does not affect the actual work the cam has to perform, but from a practical point of view it is advisable to avoid an extreme or sudden change in the cam's action, so that slightly more rounded corners are the best. In the next place, there is a different method of lifting the catch E out of gear with the notched plate F. In this case the cam plate is dispensed with, and in its place a movable plate L is fastened to the back of the grooved cam B. Its position can be easily altered to suit the requirement by means of the screws M, this plate during the revolution of the cam B being brought under the bowl K (which in the drawing happens to occupy the same position as the centre D of the notched wheel), and raises it so that the catch E is lifted out of gear with F. The cam B itself can be adjusted to the necessary conditions of timing, etc., by its connection with the plate P and bolt Q.

The cylinder N is shown in its relative position to the other portions of the drawing.

We now come to the consideration of the means employed to raise the leather detaching roller E out of and into contact with the fluted segment of the combing cylinder. It will be understood from previous descriptions that the leather-covered roller is always in contact with the bottom fluted detaching roller D, and is kept so by means of weights or springs. During the backward motion its revolution is given to it purely by the friction of itself with D, but directly the forward motion commences, it falls into contact with the fluted segment of the cylinder, and this motion helps to cause E to rotate. Now, unless the surface speed of D is timed exactly like the surface speed of the cylinder, we can readily see that the roller E

between the two surfaces will suffer considerable damage to its leather covering, as well as producing inferior results. To prevent this occurring, the cam grooves which actuate the quadrant or the notch wheel are very carefully designed, and in some cases every cam is milled out so as to ensure a perfect action.

In Fig. 39 an illustration is given which will show very clearly the method of actuating

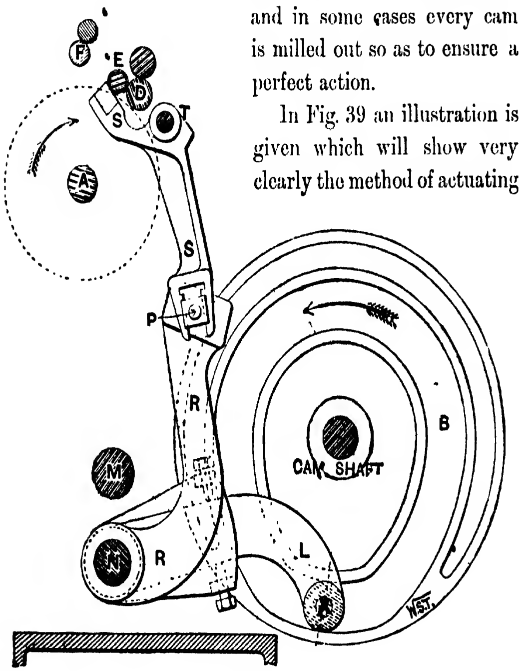


FIG. 39.

the leather detaching roller. A cam B fixed on the cam shaft has working in its groove a bowl X, which is carried by a lever L centred on the shaft N. The shape of the cam groove is such as to cause X to approach and recede from the cam shaft centre, and through this motion the shaft N receives a rocking action. On the same shaft N is fixed a series of levers R, which carry a stud P. This stud works in a slide

formed in one end of the lever S, which has T as its fulcrum, and whose other end provides the surface upon which the ends of the leather detaching roller rest. We can now see, by following the movement of X as it is changed by the

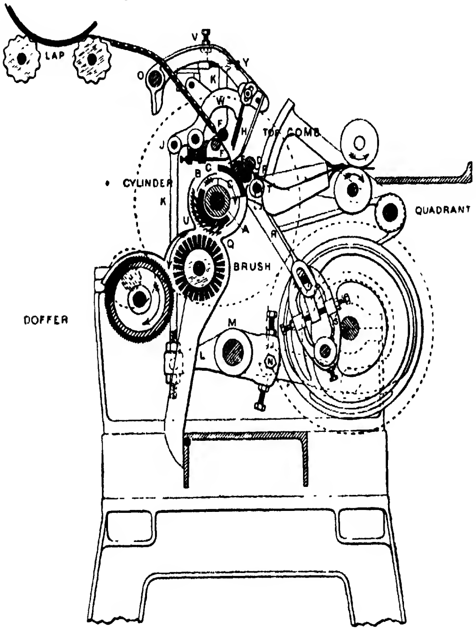


FIG. 40.

special form of the cam B, that its motion will affect, through the levers R and S, the position of the roller E. In the position shown in the drawing (Fig. 39), E is working in contact with the cylinder, and so assisting in the forward motion, but the further revolution of B will lift it out of this position, and keep it so until the flutes of the cylinder again return to the necessary place for the

repeated action. Adjustments can be made for the extreme exactness that is required, by the setting arrangement on the lever L, and also by the regulating of the stud P.

Fig. 40 shows Dobson and Barlow's improvement on

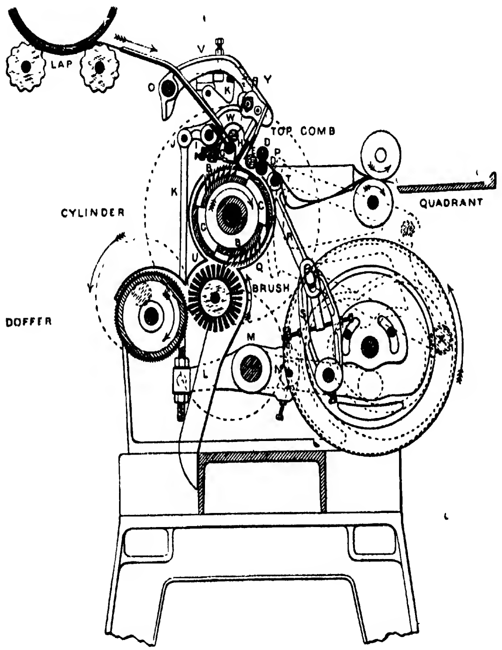


FIG. 41.

their old method as depicted in Fig. 39. The levers have been rearranged and reduced in number, there are therefore less moving parts, and an action free from vibration and of a more capable and delicate adjustment is obtained. Fig. 41 illustrates its application to the double form of comber, and this drawing may be found useful in connection with the description on page 58.

A review may now be made of the previous descriptions of the various actions produced by the mechanisms just described, as far as they all affect that portion of the machine just above the cylinder. A series of drawings has been prepared illustrating that region of the machine, and from them the following explanations will be summarised.

In Fig. 42 the feed rollers F have delivered a suitable length of staple, the nippers G H have closed up and hold it fast, and the cylinder teeth are upon the point of commencing to comb it. It will be noticed that the first rows of teeth are of a coarser pitch than the others that follow. The teeth themselves are also longer, stronger, and farther apart. Each row gradually becomes finer in this respect until the last row, which is composed of a large number of very fine needles close together. The object of this arrangement is to act progressively on the cotton. The coarser needles prepare it for the finer ones which follow, and so the fibres are treated in a way that ensures the minimum of damage with the maximum of cleaning. The top comb is out of the way, and the sliver previously taken through is shown to be in a position ready for the backward motion.

Fig. 43 is practically the same drawing, but showing the conclusion of the combing action. It will be seen that the cotton already taken forward is quite separated from that just combed, so it is necessary to piece it up, and this is performed by an overlapping process.

In Fig. 44 this process is shown. The roller D has been turned in a backward direction, and presents a length of cotton ready for piecing. The roller E has been placed on the fluted segment, and naturally grips the end of the combed cotton, which, during its revolution, it carries forward and overlaps on the returned portion, so that an

effective joining is the result. Just before this action however, the nipper is opened and the top comb T comes down into the path of the lap, so that as E carries the

FIG. 42.

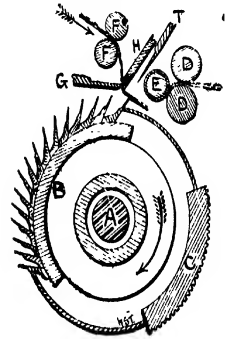
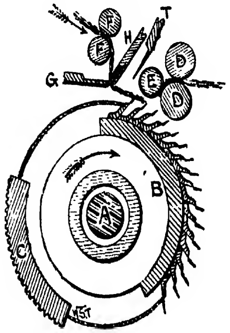


FIG. 43.



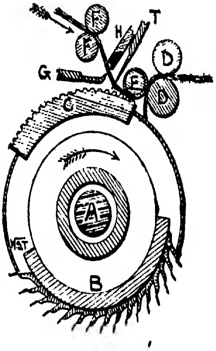


FIG. 44.

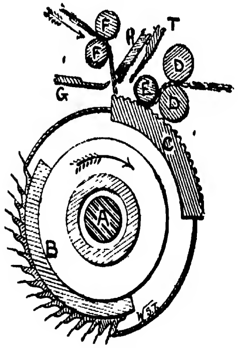


FIG. 45.

cotton forward it is drawn through the needles of T and receives a good combing. Fig. 45 illustrates the finishing cycle of movements, and shows E to be on the point of being raised out of contact with the cylinder; the rollers

are delivering cotton for the approaching combs, and directly this is done the nipper will close.

It may be as well at this point to note that the amount of cotton taken forward by the detaching roller is not equal to the amount combed; only the longest fibres are taken forward, so that the remaining fibres, augmented by the fresh fibres fed by the feed rollers, are again combed, and probably the majority of fibres, before being absolutely free to pass forward, are combed several times.

In regard to the cylinder itself, it is now generally made so that the greatest facility is afforded for taking it to pieces and replacing very quickly damaged portions. As a rule, it is built up in segments around the centre, and is composed almost entirely of turned work, in which form duplication becomes an easy matter. Each row of needles can be removed for repairs without interfering with the rest, so that the former arrangement, which caused great difficulty in this respect, is completely altered and improved.

It used to be the common practice to make combers to take only laps up to 7½ in. wide, but at the present time improvements have been made in the way of guides on the cushion plate, which prevent bad selvedges through spreading, and enable a wider lap to be used without increasing the length of the machine. But machines are not now confined to narrow laps. Up to 10½ in. laps are frequently made both for the single and double form of the comber. Six to eight heads are the usual number forming one machine.

So much improvement has taken place in the comber during the last few years that its production has been greatly increased, and the number of nips per minute, which used to be about 60, has gone up by degrees until now

many machines at work giving good results are running at 96 and even 100 nips per minute.

The comber takes to drive it about $\frac{5}{8}$ i.h.p. to $\frac{7}{8}$ i.h.p. according to the following table:—

Ordinary . . .	6 heads.	$\frac{5}{8}$ i.h.p.	8 heads,	$\frac{3}{4}$ i.h.p.
"Duplex" . .	6 ,,	$\frac{3}{4}$,,	8 ,,	$\frac{7}{8}$,,

The pulley varies in size and speed according to the make of machine, one maker using a 12-in. pulley at 230 revolutions, whilst another, with a 10-in pulley, runs at 325 revolutions.

The following tables will be useful as conveying much valuable information on the comber, and presenting several points of interest to the student:—

ORDINARY COMBER.

No. of nips per min.	Weight of lap per yd.	Width of lap.	Waste per cent.	Lbs. per head of combed sliver.	Kind of Cotton.
	dwts.	in.			
80	8	$7\frac{1}{2}$	20	6·37	Sea Islands.
80	9	$8\frac{1}{2}$	20	7·22	,, ,,
80	11	$10\frac{1}{2}$	20	8·92	,, ,,
80	9	$7\frac{1}{2}$	18	7·5	Egyptian or American.
80	$10\frac{1}{2}$	$8\frac{1}{2}$	18	9·0	,, ,,
80	13	$10\frac{1}{2}$	18	11·15	,, ,,

The above productions are based, as will be seen, on a speed of 80 nips per minute; but if, as is now the case, machines run up to 100 nips, the production, of course, will be correspondingly increased.

"DUPLEX" OR DOUBLE COMBER

No. of nips per min.	Weight of lap per yd.	Width of lap.	Waste per cent.	Lbs. per head of combed sliver.	Kind of Cotton
	dwts.	ins.			
120	8	7½	20	9·23	Sea Islands.
120	9	8½	20	10·47	,, ,,
120	11	10½	20	12·93	,, ,,
120	9	7½	18	10·88	Egyptian or American.
120	10½	8½	18	13·04	,, ,,
120	13	10½	18	16·12	,, ,,

Heavier productions than these can be obtained if more medium qualities are desired, but for the best work the above results represent a good average.

The necessity for great care and experience in the management of the comber will be apparent to all who have followed carefully the description of this complicated machine. The setting of the various actions demands extreme exactness and a knowledge of the material being worked, or else considerable waste and probable damage to some part of the machine will result from such negligence. Waste may be increased more than is desirable by several causes—for instance, if the nippers do not close at the right moment, that is, before the needles reach the cotton. This is generally spoken of as the nipper closing too late. Feeding too late produces excessive waste, and the angular position of the combs on the cylinder gives a similar result. The setting of the top comb in relation to the cylinder and nipper, unless carefully performed, yields more waste than is necessary, and consequently too close setting is to be avoided. The method of setting and the gauges used for

the operation vary of course with different makes of machines, so that little purpose would be served in giving the *modus operandi*. It will be sufficient to intimate that the following points are important items in the process:—The distance between the flute of the detaching roller and the front edge of the fluted segment of the cylinder; the distance between the detaching roller and the cylinder; the distance between the edge of cushion plate and the fluted detaching roller; the position of the cushion plate relative to the needles on the cylinder when the nipper is closed; the distance apart of the feed roller and the fluted detaching rollers. In addition to these, facilities are provided to enable each action to follow in its proper order. An index wheel is marked with numbers suitable for various settings, and by turning these numbers to the fixed pointer, the cams, cylinders, etc., can be fixed on their shafts, and adjusted correctly for any given set of conditions. In order to convey an idea of the numbers used, the following table is given, and represents the practice and arrangement of a well-known firm of machine-makers, whose work on this machine amounts almost to a specialty:—

	EGYPTIAN.	AMERICAN.
Feed rollers move at	1½ to 5*	6¼* to 4¼
Detaching roller moves forward at .	6* ,, 6⅛	6⅞ ,, 5¾
Detaching leather roller touches segment at	6 ,, 7¼	6¾ ,, 6½
Top comb comes down at . .	5½ ,, 6¼	not lifting 4
Nipper closes at	8¾ ,, 9¼	10¼ ,, 8¼
Clutch wheel in gear at . . .	0½ ,, 1½	0¾ ,, 0½

Those marked with an * in the Egyptian column are

considered very good times, whilst the ones marked with an * in the column for American cotton are settings for the best quality.

. There still remain a number of details to be pointed out which have an important bearing upon the work of the comber, but they can, however, only be briefly mentioned here. In the first place, absolute cleanliness of the machine is a condition that cannot be too emphatically insisted upon. It must be clear to all that it is useless making an effort to obtain the very best fibres from any class of cotton, and arranged in a manner calculated to give the strongest result if, through carelessness or ignorance, some of the impurities taken out are allowed to be returned, or even when the effective capability of the machine is somewhat neutralised by the same cause. It is a comparatively easy matter to allow the comber to do its work indifferently, but the greatest care must be exercised if the very best results are desired from it. The continued or intermittent movements of the various parts set up vibrations and currents of air, having a strong tendency to dissipate the delicate fibres or the loose cotton taken out of them as waste. This must be prevented, and we find that arrangements are made with this object in view, so that the collection of the waste and the cleansing of the rollers is performed in some systematic manner.

On referring to Fig. 29, where a section of the comber is illustrated, it will be noticed that a circular brush is shown, the bristles of which are pressed against the needles of the cylinder to the depth of $\frac{1}{8}$ in. to $\frac{1}{4}$ in. Its revolution in the direction indicated freely clears the teeth of the fibres combed out of the cotton, and does it in a way that reduces to a minimum the possibility of fluff flying about. Its speed is greater than that of the cylinder, but the mere

fact of its movement at the point of contact being the same, and also because the angular position of the needles is favourable, a thorough clearing is ensured. It must be understood that the cylinder can only be kept clean if the various rows of needles are perfectly joined up to each other. When even the slightest space exists between the rows of combs, an opportunity is given for accumulations of waste as well as interference with the work of the needles. Much damage is done to cotton through bad workmanship in this respect, and what is technically known as "flocking" is a frequent occurrence. The brush itself, through its continual movement and rubbing against the cylinder, naturally wears to a smaller diameter, and consequently requires readjustment both for position and speed, or otherwise the needles are not cleaned. The cotton on the brush, in its turn, must be taken away, or ultimately the cylinder would pick it up again, so a spiked doffer is used, whose teeth clear the waste from it. The doffer is stripped by means of a vibrating comb in a similar manner to the comb of the card, but, of course, running much more slowly. The waste comes off in a thin fleece or web, and falls into a suitable receptacle arranged to receive it. In some machines the web of waste falls from the doffer upon a slowly revolving shaft, which winds it in the form of a lap, and in this way it is collected in a very neat and compact manner.

What is termed an aspirator is sometimes applied in collecting the comber waste. It consists of a revolving perforated drum or cage set close to the circular brushes in place of the doffer and comb. The cage is fitted with dampers, and a fan draws air through the portions left uncovered and so sucks the fibres from the brushes. These fibres, on the surface of the revolving cage, are carried round

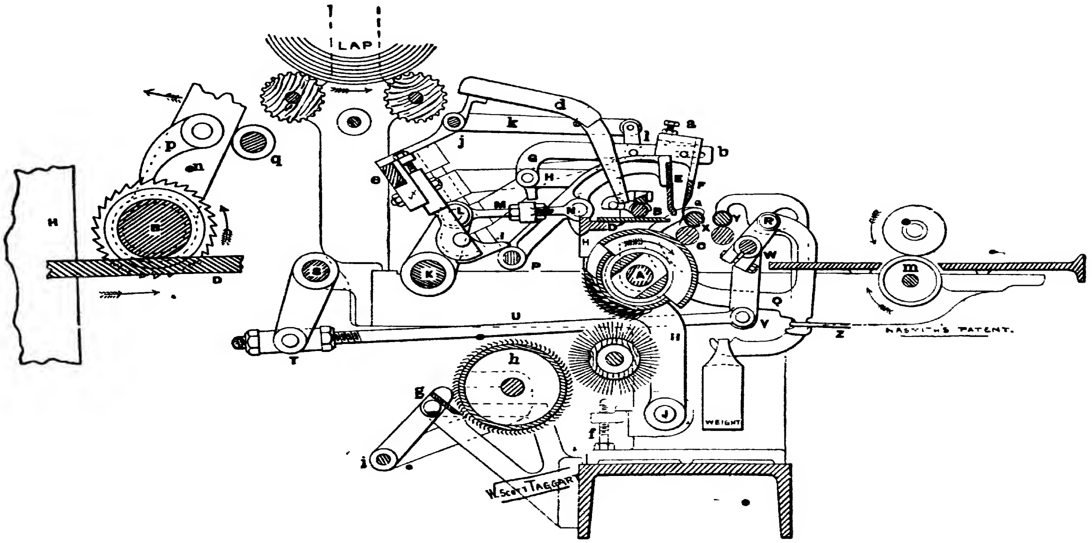
and are deposited on a travelling lattice which conducts them to a coiler at the end of the machine, where they are coiled into a can. At the same time all the dust and loose fibres flying around the comber are sucked into the aspirator, and the machine is kept much cleaner and the air purer by the device; its cost probably keeps it from a general use.

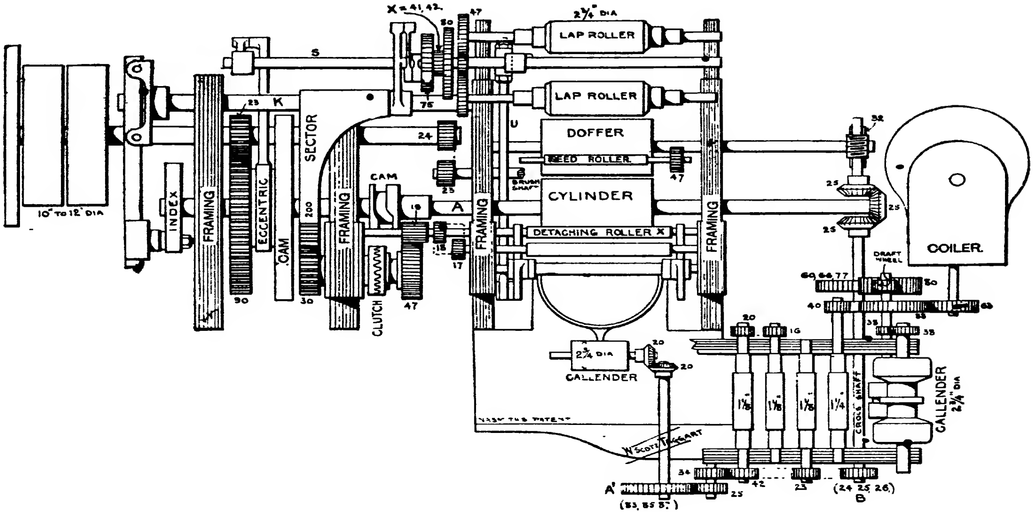
The feed rollers are kept clean by means of a brush pressing against them, whilst the detaching rollers are supplied with movable clearers covered with flannel. In order to prevent the escape of waste, and as a protection also, the cylinder, etc., is carefully covered in by tin casings. These are shown in Fig. 29, at Q and U. They are made so as to be readily removed in case of necessity.

Nasmith's Comber.—A general view of the section of this machine is given in Fig. 46. Some of its features are similar to the Heilmann comber previously described, so a brief description only is necessary in connection with this illustration.

The lap from the ribbon lap machine is placed on the two lap rollers and the sheet of cotton led downwards and underneath the roller B mounted on a plate D. The sheet passes over the edge of this plate, where it is nipped by the nipper E, whilst it is combed by the teeth of the cylinder A. From this point it is taken forward by the detaching roller X after this latter roller has made the overlap or piecing. The rollers Y now continue the forward movement of the sheet, and after it has passed through the usual funnel it is taken forward by the calender rollers "m" in the usual manner.

The plan view Fig. 47 will now enable a few more essential facts to be noted. The driving shaft has a 23[s] wheel driving a 90[s] wheel on the shaft A or cylinder shaft. On this shaft is fixed the index disc, and on this disc is a


LAP
WEIGHT
NASMYTH'S PATENT.
W. SCOTT TAGGART



X = 41, 42.
2¼" DIA
LAP ROLLER
LAP ROLLER
S
K
SECTOR
DOFFER
FEED ROLLER
CYLINDER
DETACHING ROLLER X
INDEX
FRAMING
ECCENTRIC
CAM
CLUTCH
COILER.
DRAFT WHEEL
CROSS SHAFT
CALLENDER
2¾" DIA
10" TO 12" DIA
BRUSH SHAFT

FIG. 47.

pin to which is connected a rod which extends backwards to a lever on the shaft K; the revolution of the index disc acts as a crank and gives a rocking motion to the shaft K. The sector or quadrant rides loosely on K, which thus acts as its centre. An eccentric on the cylinder shaft A gives a rocking motion to the shaft S. The cam on A operates the sector or quadrant through which the backward and forward motions are given to the detaching roller. The rest of the drawing partakes very much of the features with which the reader is already familiar in the Heilmann comber.

By keeping these brief notes of the main features of the machine in mind, the following descriptions of the details will be easily followed. On reference to Fig. 48, a lever H is centred on J; this lever carries a bracket to which a plate D is fixed and a bearing for the roller B. The same bracket is also designed to be coupled up at N by a link or adjusting rod M to a lever L on the rocking shaft K; we can now see that the rocking shaft K will give a to-and-fro movement to the lever H and consequently to the plate D and its roller B. This plate D is the nipper plate and its roller is the feed roller. On the end of the feed roller is a wheel (see small sketch in Fig. 46) and a lever "n" carrying a pawl "p," the whole being carried forward by the lever H. The lever "n" during this movement comes against an adjustable stop "q" and is arrested; but lever H continues to go forward, and as a consequence the pawl "p" acts as a driver to roller B, and causes it to revolve and so feed the sheet of cotton forward in the direction the nipper plate D is moving. The stop "q" can be regulated to give the feed required. This brief description is sufficient to show us that the nipper plate is moved by a simple crank motion, no cam

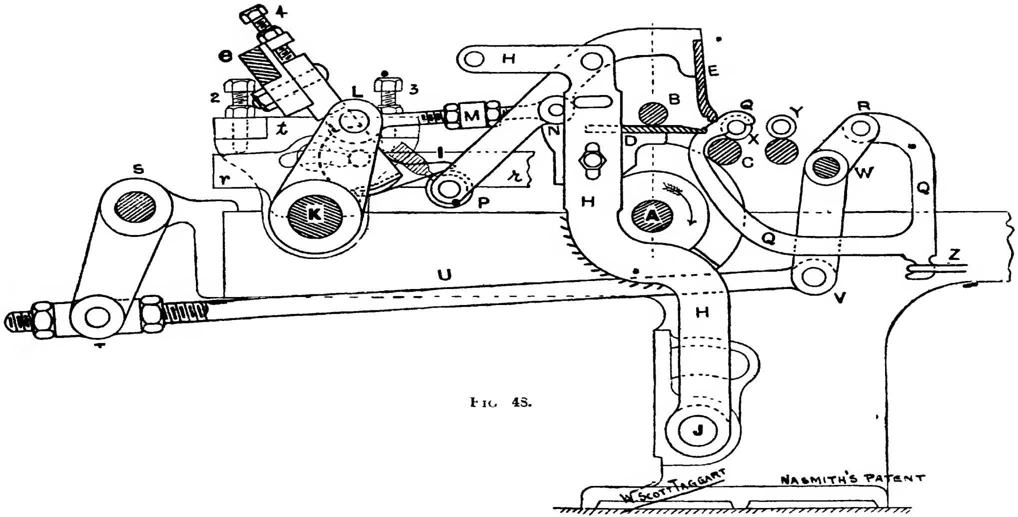

4
6
2
3
L
M
H
H
E
B
Q
Y
R
X
C
W
N
D
t
I
r
r
S
K
P
H
A
Q
Q
Z
U
V
H
J
W. SCOTT TAGGART
NASMITH'S PATENT

FIG 48.

being required, and that the intermittent feed motion dispenses with the usual Geneva stop or star wheel feed. It will also be noted that there is always a sheet of cotton between the feed roller B and nipper plate D and extending to the edge of the plate. The forward movement of the lever H results in the previously combed length being detached, and a new length is delivered ready for combing; the backward motion of the lever H brings this newly-fed length of cotton into position for the needles of the cylinder to pass through it; but previous to this happening, the top nipper has come down and gripped the projecting cotton against the nipper plate, the grip being metal and metal, for no leather is used. It is interesting to note how the nippers are opened and closed. The top nipper E in Fig. 48 is carried by a lever centred at N and whose other end carries a bowl P. This end of the lever has a spring connected to a fixed part of the framing and its tendency is to close the nippers. As the forward movement of the lever H is finishing the bowl P comes into contact with an inclined foot "1," and so opens the nippers against the pull of the spring. On the return movement the bowl leaves the inclined foot "I" and the spring at once closes the nippers, and the projecting cotton is gripped ready for the combing action. The inclined foot "1" is adjustable, so that the opening and closing of the nippers are easily regulated. The drawing Fig. 49 shows clearly the parts in their backward position, so that a comparison of the two drawings is advisable in following the description. In reference to the top comb a separate sketch is given in Fig. 50 that will convey some idea of its action. It will be seen that the top comb F is carried by a bracket bolted to a lever G that is centred on an extension of the lever H. The movement of H will

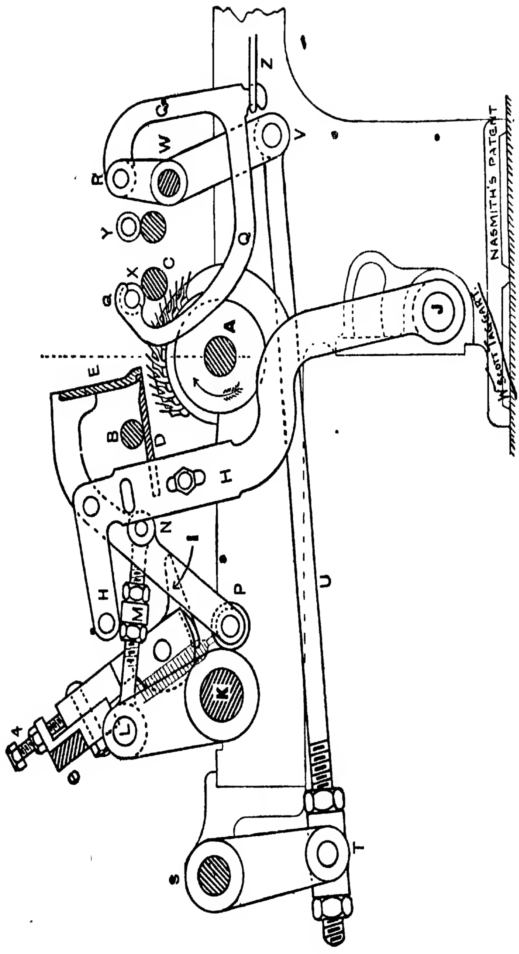


Fig. 49.

therefore carry the top comb to and fro. On the top comb lever is a bowl or pin "14," which, during the backward motion of the lever H, comes into contact with a fixed inclined arm "15" so adjusted that the top comb is raised and clear of the cotton, but on the forward movement nearing completion the bowl passes off the incline and falls, the extent of the lowering of the comb being regulated by the adjusting screws "x." The exact position

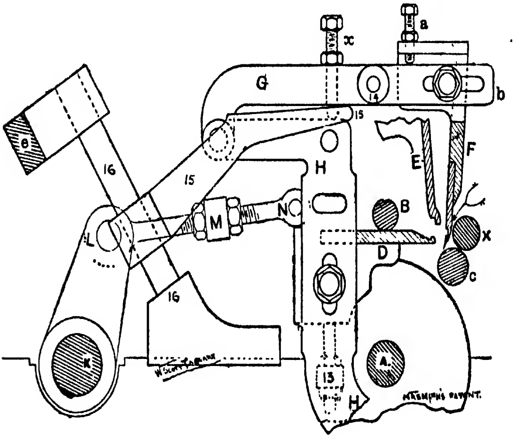


Fig. 50.

of the comb is obtained by the slots "b" in the lever G and the regulating screws "a."

A brief reference may now be made to the detaching mechanism, for which purpose a glance at Fig. 51 may be made. The upper figure shows the cylinder needles combing the cotton, the nippers being closed and in their backward position. Before this combing action is completed, and whilst the finer rows of needles are in action, the nipper plate commences to move forward, and as this movement is in the same direction as the moving needles

the combing action becomes gentle and the fibres freed from strain. In the right hand side figure the needles have passed and the nipper plate has advanced about half

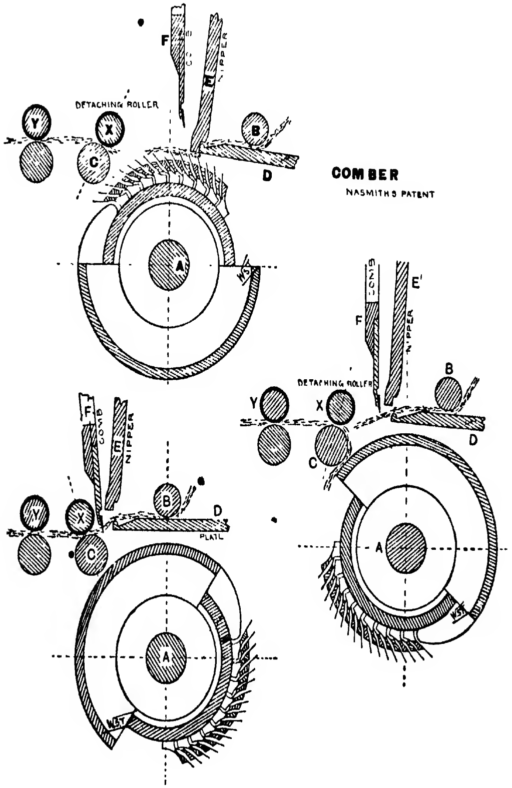


FIG. 51.

way towards the detaching rollers, but just previous to this position, and as the last row of needles pass the detaching rollers, the latter are given their backward motion through the sector or quadrant; this cotton that

has been returned is projected into the space between the needles and the plain segment of the cylinder, and this is the more easily effected by reason of the forward position, relative to the cylinder, of the detaching roller X. The fleece is therefore bent under the bottom roller, and a clear surface of cotton is presented for the newly combed portion to be pieced to it. As this is taking place, the nippers have opened and the released combed cotton rises and points in the direction of the detaching rollers are indicated in the sketch. The top comb in the meantime begins to fall. The detaching rollers now commence to turn forward and the nipper advances, so the combed cotton is laid on the previously returned portion and the whole taken forward until the nipper completes its movement; the top detaching roller is moving away slowly during this period, whilst the nipper is advancing more quickly; the detaching rollers continue to turn a moment longer after the nipper has stopped, and this commences the separation or detaching, an action that is completed when the nipper begins its return movement. It will be seen from this description that the nearness of the grip of the detaching rollers to the nippers is obtained by moving the top detaching roller towards the nippers and then away from them in the delivery; this method entirely dispenses with any contact with the cylinder, so no fluted portion is necessary in this latter organ. A plain circular portion is therefore substituted. Both Figs. 48 and 49 show how the movement of the top detaching roller is effected. The rocking shaft S, through the lever T and connecting rod U, operates the front levers and so brings about the to-and-fro movement of X, the roller being kept in contact with the bottom roller C by a weight hung by chains to the lever Q at Z. The eccentric, on the cylinder

shaft A, and its connection to the rocking shaft S is shown in the sketch Fig. 52. Adjustments are fully provided for in the setting of the roller and its precise moment of action.

A further illustration in Fig. 53 is given to show the method of rocking the nipper shaft K. It is a crank motion, but, owing to the sliding block moving along the lever "r" as the index disc 8 revolves, a variable leverage results, giving a form of quick return motion. The small diagram in Fig. 54 will give some idea of the variable

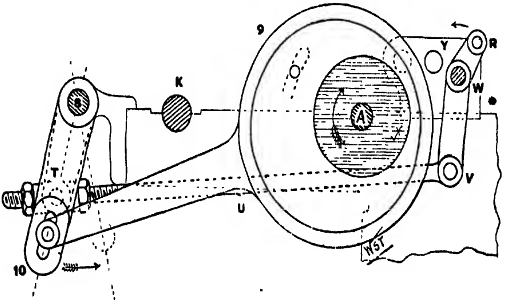
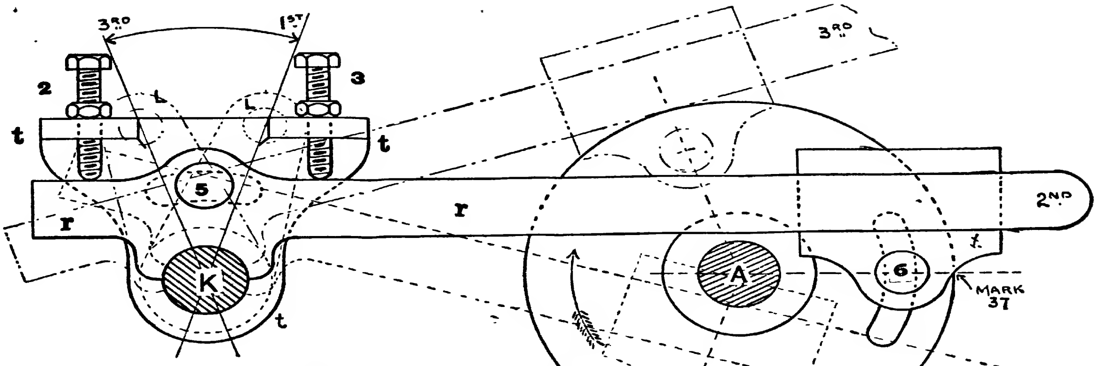


Fig. 52.

character of the movement produced by the crank action; the commencement and ending of both the forward and return stroke are gentle, and all shock is avoided. It is characteristic of the whole machine that all the various operations are free from sudden actions. It remains to point out that this machine, whilst capable of combing a wide range of staple (it will equal the Heilmann in combing the longest Sea Islands cotton with an advantage of double its production under ordinary conditions), finds its greatest value in the combing of shorter stapled cottons, even cotton of $\frac{7}{8}$ inch staple being easily manipulated. This arises chiefly from the fact that the



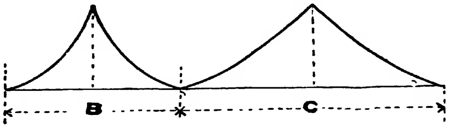


Fig. 54.

Fig. 53

piecing operation enables a very long piecing to be made, much longer than the length of the staple is itself, and the result gives a uniform and regular sliver not disfigured by the frequent unevenness seen in the Heilmann comber. The waste extracted is well under control and can be brought down to a low percentage on short stapled cotton.

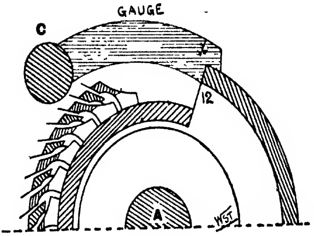


FIG. 55.

The setting of the various parts are readily carried out and the timing of the various operations clearly indicated, so that when the machine is once understood, it presents little difficulty to the practical man.

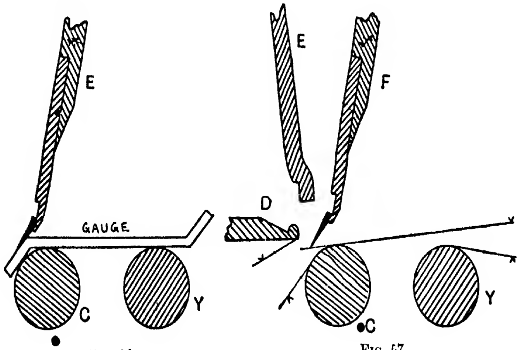


FIG. 56. FIG. 57.

Figs. 55, 56, and 57 illustrate the gauges and the chief dimensions requiring attention in setting.

In Fig. 56 the gauge shown is $\frac{1}{16}$ inch and it is used to fix the distance of the top comb from the bottom detaching

roller C, the simple purpose of course being to so set the comb that it is free from any contact with C.

Fig. 57 represents the distance between parts that have an influence on the cleanliness and regularity of fibres of the cotton or the amount of waste taken out. The space between the bottom nipper plate and the surface of the bottom detaching roller is set by means of a stepped gauge marked with numbers 8, 9, 10 up to 16, these numbers representing 32nds, so that we have spaces equal to $\frac{8}{32}$, $\frac{9}{32}$, $\frac{10}{32}$ up to $\frac{16}{32}$, or a variation of settings from $\frac{1}{4}$ to $\frac{1}{2}$ inch. It may be noted that it is extremely difficult to set this distance to the $\frac{1}{4}$ inch gauge. At the same time a compensating setting that has some considerable influence is the distance of the feed roller from the bottom detaching roller, and by moving the feed roller nearer to the front of the bottom nipper less waste is made, and *vice versa*. Of course the greater the distance between the nipper D and the roller C the greater the percentage of waste. The usual settings are given as

$\frac{1}{4}$	inch for	American.
$\frac{5}{16}$ to $\frac{3}{8}$	"	Egyptian.
$\frac{3}{8}$ to $\frac{9}{16}$	"	Sea Island.

The gauge used (doctor gauge), that rests under tips of top comb and on the top of roller C, will usually leave a space between the gauge and the top of front detaching roller Y. The greater this distance the larger the percentage of waste taken out, simply because the top comb will enter the web to a greater length of its needles, and so take out more fibres. In some cases, of what may be termed semi-combed yarns made from heavy laps and medium cottons, the top comb is set so that the gauge also rests on the front detaching roller Y.

Weight of Laps.—Width of lap $10\frac{1}{2}$ inches wide.

For longest Sea Island cotton	. .	12 to 18 dwts. per yard.
,, other ,, ,,	. .	18 ,, 22 ,, ,,
,, Egyptian Cotton	. .	24 ,, 27 ,, ,,
,, American ,,	. .	26 ,, 32 ,, ,,

Speeds.—The speeds are variable for different classes of cotton, but in general they may be taken as follow :—

For best Sea Island cotton .	.	335 revs. per min ,	86 nips per min.
,, other ,, ,, .	.	350 ,, ,,	90 ,,
,, Egyptian cotton .	.	370 ,, ,,	95 ,,
,, American ,, .	.	390 ,, ,,	100 ,,

Production.—This of course depends on several factors, such as speed, weight of lap, and amount of waste extracted. If allowing 15 per cent waste when working a 25 dwt. lap at 100 nips per min., the production of a six-head comber will be about 800 lbs. in a week of 50 hours.

Power.—The Nasmith comber of 6 heads requires about $\frac{3}{4}$ of a horse-power.

An enlarged view of a portion of the Heilmann comber as made by Hetherington's is shown in Fig. 58. Incidentally the drawing illustrates a sliver stop motion which can be applied if necessary. The funnel C is made separate from the sliver tin and carried by a lever centred on a knife edge fulcrum A; when an end breaks or no cotton passes forward, the other end of the lever at B interferes with a vibrating lever D, actuated by an eccentric on the cam shaft through the levers G and F, which releases the slide bar J, unlocks the stop rod K, and so stops the machine. Stop motions ought to be applied to all combers, their extra cost is quickly saved in the quality of work produced.

A further sketch, from the same make of comber, is

given in Fig. 59, which shows **a full can measuring or stop motion.** The bottom calender shaft actuates a lever which through the pawls turns the ratchet wheel, this revolves the worm gearing into the worm wheel, a pin on

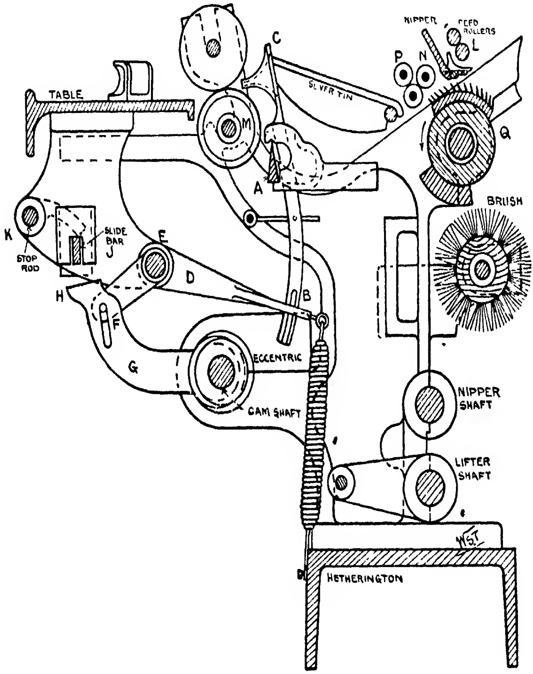


FIG. 58.

the latter is brought into contact with the slide bar and releases the stop rod, thus stopping the machine. Changing the ratchet enables a control of the length of sliver required to be easily obtained.

Whitin Comber.—This comber, made by Howard and Bullough, is an adaptation of the Heilmann comber. In

essentials it is the same machine, but a simplification of various parts enables a higher speed to be run by the cylinder with a corresponding reduction in vibration. A section of the machine is given in Fig. 60, and the various

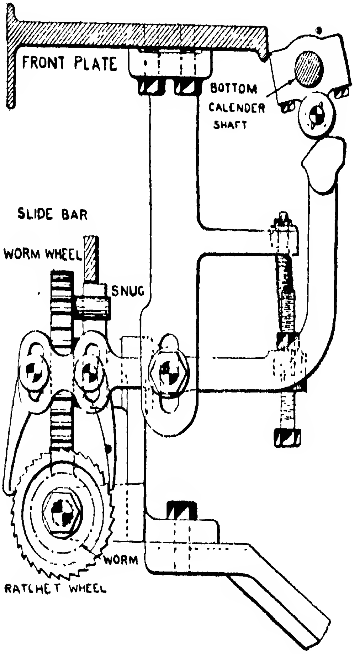


FIG. 59.

features can be followed out by a reference to the names of the parts accompanying the sketch.

It will be noticed that the section could practically be taken as representing the Heilmann comber, and the description of this latter machine is applicable. The improvement or rather the variations from the Heilmann consist chiefly in eliminating the movement of the leather

detaching roller; this roller is kept in one position, so no cam is required. As a consequence the cylinder speed can be greatly increased, so that up to 130 nips per min. are readily obtained. The speed of the cam shaft is kept down by the simple method of making a double cam for

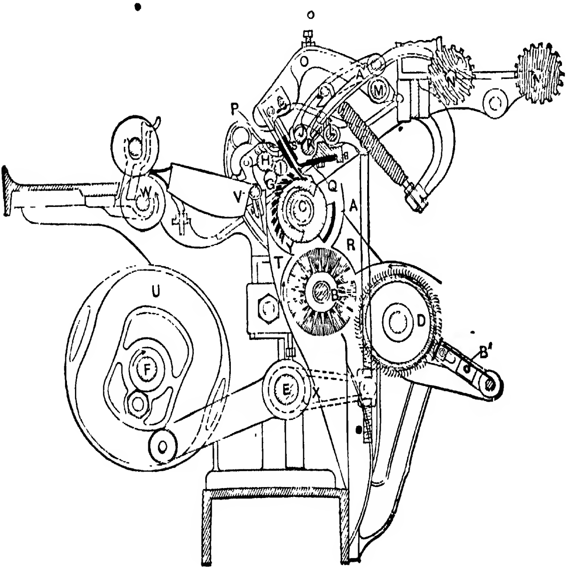


FIG. 60.

- A Plain segment.
- B Brush.
- C Cylinder.
- D Doffer.
- E Nipper shaft.
- F Cam shaft.
- G Steel drawing-off or detaching roller.
- H Brass detaching roller
- I Leather detaching roller.
- J Top feed roller.
- K Bottom feed roller.
- L Nipper arm fulcrum.
- M Top comb shaft.
- N Lap roller shaft.
- O Top comb arm.
- P Top comb.
- Q Cushion plate.
- R Doffer cover.
- S Nipper knife.
- T Waste chute.
- U Nipper cam.
- V Horse-tail holder shaft.
- W Calender roller shaft.
- X Nipper shaft lever.
- Y Half lap.
- Z Top feed roller saddle.
- A_1 Lap plate.
- B_1 Waste packer.

operating the nipper. The cycle of actions in combing the cotton can easily be understood on reference to Figs. 60A,

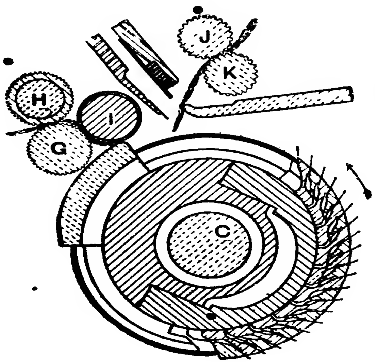


Fig. 60a.
Showing portion of lap advancing prior to combing.

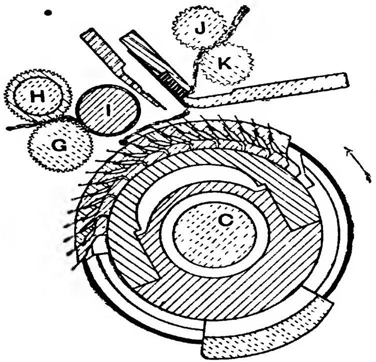


Fig. 60b.
Cylinder combs in operation.

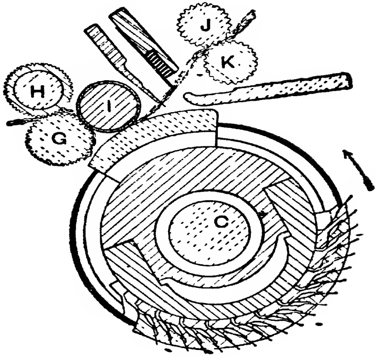


Fig. 60c.
Top comb in operation.

60B, and 60C, which show the various organs at different stages of their movements. In general this comber is applicable for all purposes for which the Heilmann is used, whilst in addition it is also well adapted for reclaiming the large proportion of good fibres found in card strips, these latter amounting to sometimes 60 per cent of the waste.

The setting of this comber follows somewhat similar lines to that of the Heilmann. For ordinary purposes it will be found that the nippers close at 11½ on index wheel. The detaching roller moves forward at 6, and the feed roller moves at from 3½ to 6½ according to the percentage of waste required to be extracted. The increase of waste may be obtained by setting the top comb closer, by feeding later, by putting more angle on the nipper knife and top comb. Weights of laps weigh from 400 to 550 grains per yard.

The production varies from 700 to 900 lbs. per week of 55 working hours.

All the usual motions for reducing wear and tear, stop motions, taking up wear of brushes and running at correct speeds, collecting waste, etc., are applicable to this machine as to the other combers described.

Nippers.—The nippers previously described are made by most firms who manufacture combers, but a special form has been adopted by Dobson and Barlow's which has advantages. An illustration is given in Fig. 61. It will be noticed that the nipper knife is covered with leather or other soft material. This simple device enables the setting of the nipper to the needles of the cylinder to be extremely fine; there is no danger of the needles being destroyed by contact with the metal as frequently happens in the previous types of nippers, so that, from this point of view alone, the new method is a means of saving considerable

time and money in the course of a year. In addition to its protective advantages, the finer setting enables a thicker lap to be used and a corresponding increase in production ranging from 30 to 60 per cent.

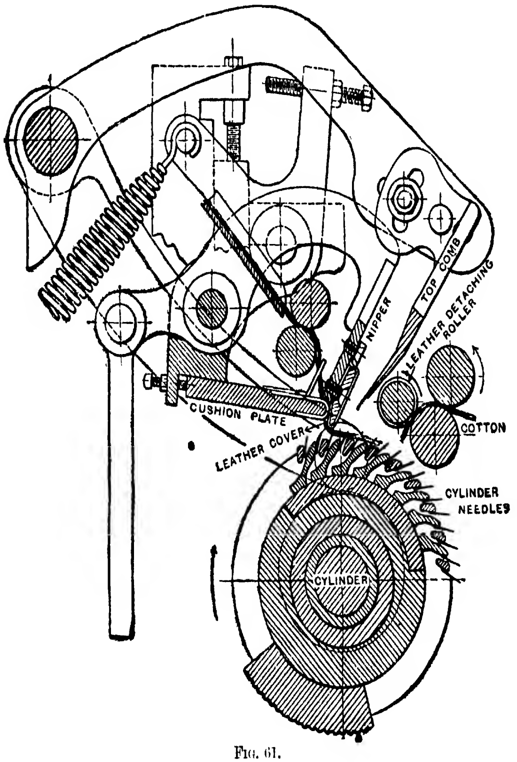


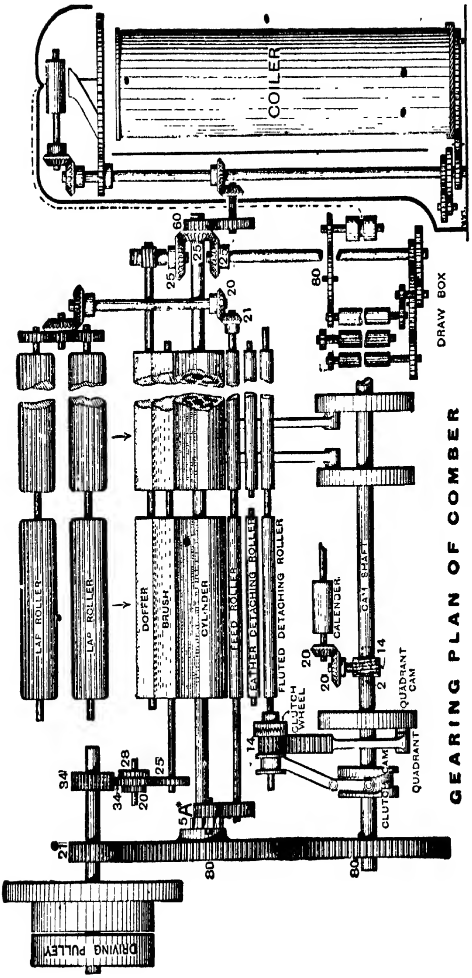
FIG. 61.

In Fig. 62 is presented a part plan of the comber, arranged with the object of showing the whole of the driving mechanism and gearing. From it can be traced the method of driving each separate action, and by using

it also for reference, when reading the previous description of the machine, a more intelligent idea of its motions will probably be obtained. It will be noticed that one complete head is shown, and part of another. If the whole of the comber had been drawn in plan there would have simply been a repetition of the first set of rollers and cylinder to six or eight heads, each head of which works precisely alike, and delivers its own combed sliver. These slivers travel along a smooth, polished plate, parallel to the length of the machine, to the end, where they are passed through a draw-box, consisting usually of three lines of rollers, as shown in the drawing. At this point the combined slivers undergo a draft, which, of course, varies according to the purpose required. From the draw-box it continues its course, after passing through a pair of small calender rollers, to the coiler, a full section of which is shown on the right of the illustration.

The driving of the machine takes place through the pulley shown on the left. This pulley is keyed on a short shaft firmly carried by the framing, so that no vibration can possibly exist. Its motion is balanced by a fly-wheel in order to prevent fluctuation of speed, owing to the intermittent movement of some of its actions. On the driving shaft is fixed a pinion, which, in the single comber, drives direct on to the cylinder through a large wheel of 80 teeth. This wheel, in its turn, drives the cam shaft through a similar wheel, so that the cylinder and cam shaft revolve at the same speed. On the cam shaft is shown the disposition of the various cams, etc., an enlarged view of a portion of which has been given in a previous drawing. The calender roller is also driven from this shaft by worm and worm-wheel arrangement.

The feed roller is driven from the cylinder shaft, as



GEARING PLAN OF COMBER

Fig. 62.

already explained, by the star wheel and gearing at A. A is a change place in order to alter the feed according to the length of the staple being worked. As pointed out, the feed roller drives the lap roller, the gearing of which is clearly shown in the sketch.

The brush is driven from the driving shaft through carriers, which may be worked as a simple carrier, as represented in Fig. 62, or as a compound carrier, by simply changing the wheel into which the 34's on the driving shaft gear.

On the opposite end of the cylinder shaft to the driving pulley is an arrangement of gearing by means of which the draw-box is driven, and also the coiler and doffer. Very little changing is done on the comber in regard to the gearing after it has left the maker's hand. The only places where this is effected are the feed wheel A and a change in the draw-box, but this latter is not often changed. Changes, of course, can be made to suit almost any special conditions, but these do not come under the general head of change places, and consequently they cannot be dealt with here.

"Calculations."[1]—The following particulars of the gearing will enable the necessary calculations to be made:—

Driving shaft wheel	21 teeth
Cylinder index wheel	80 ,,
Cam shaft wheel	80 ,,
Cylinder wheel	60 ,,
Coiler wheel	59 ,,
Block wheel	40 ,,
Front roller wheel	22 ,,
,, ,, ,,	34 ,,
Compound carrier in draw-box	{ 40 ,, / 45 ,,

[1] Several makes of combers are fully illustrated in gearing plans and the calculations given for them in the author's book on *Cotton Spinning Calculations.*

Side shaft wheel	14 teeth
Back roller wheel	50 ,,
Diameter of back roller	$1\frac{3}{8}$ in.
Diameter of bottom block in draw-box	$2\frac{3}{4}$,,
Diameter of calender in coiler	2 ,,
Coiler driving bevel	22 teeth
Coiler bevel	22 ,,
Star wheel	5 ,,
Cam shaft worm	double
Cam shaft worm wheel	11 teeth
Calender mitre bevels	20 ,,
Diameter of feed roller	$\frac{3}{4}$ in.
Diameter of calender roller	$2\frac{3}{4}$,,
Feed wheel	18 teeth
Feed roller wheel	38 ,,

The above particulars are taken from a machine working fine Egyptian cotton.

$$\text{Draft of draw-box} = \frac{22 \times 40 \times 50 \times 50 \times 2\frac{3}{4} \text{ in.}}{40 \times 34 \times 45 \times 14 \times 1\frac{3}{8} \text{ in.}} = 5{\cdot}13.$$

$$\left.\begin{array}{l}\text{Draft from the calender in}\\ \quad\text{draw-box to the coiler}\end{array}\right\} = \frac{40 \times 34 \times 45 \times 60 \times 2 \text{ in.}}{22 \times 40 \times 50 \times 59 \times 2\frac{3}{4} \text{ in.}} = 1{\cdot}01.$$

$$\left.\begin{array}{l}\text{Draft from the feed roller}\\ \quad\text{to the calender block}\end{array}\right\} = \frac{38 \times 5 \times 2 \times 20 \times 2\frac{3}{4} \text{ in.}}{18 \times 1 \times 14 \times 20 \times \frac{3}{4} \text{ in.}} = 5{\cdot}52.$$

$$\text{Total draft of machine} = 5{\cdot}13 \times 1{\cdot}01 \times 5{\cdot}52 = 28{\cdot}6.$$

The total draft can also be obtained by finding the draft in one operation between the feed roller and the draw-box block, and multiplying it by the draft between the draw-box and the coiler. For instance—

$$\frac{38 \times 5 \times 50 \times 40 \times 22 \times 2\frac{3}{4} \text{ in.}}{18 \times 1 \times 45 \times 34 \times 40 \times \frac{3}{4} \text{ in.}} = 27{\cdot}826.$$

$$27{\cdot}826 \times 1{\cdot}01 = 28{\cdot}1 \text{ total draft.}$$

This result is different by about 1·7 per cent from the previous method, and it is evidently owing to the waste that has been taken out. A list could be drawn up showing the difference in the two drafts and expressing it as a waste percentage.

In calculating draft it frequently happens that the actual draft differs from the results arrived at by calculation. This occurs chiefly in connection with machines dealing with slivers, such as the draw frame, sliver lap machine, ribbon lap machine, and comber. This difference must arise, because, for calculation purposes, the exact diameter of the bottom roller is taken as the basis. If the top roller were driven positively and exactly the same surface speed as the bottom roller there would be no difference, but since the top roller is driven by the bottom roller through the layer of cotton between them, and the top roller is weighted, the thickness of the cotton passing through has some influence on the draft, and brings about a difference between the calculated draft and the actual draft. The two factors of thickness of slivers and weighting of the top rollers must be taken into consideration when dealing with the question of draft. An important factor that sometimes arises in this connection is the speed of the front roller. As a rule it is presumed that the top roller will be driven regularly and easily by the bottom roller through the friction of the fibres between them, but it will be clearly seen that this cannot always take place. If the weighting is not carefully adjusted to suit both the sliver and the speed, the fibres in contact with the bottom roller will travel forward quicker than the fibres in contact with the top roller, and there will naturally be a tearing away of fibres, thus giving rise to the condition termed "spewing" as the sliver emerges from the nip of the rollers.

Comber.—Difference in weighting the leather detach roller alters the waste. 32 lbs. on detach roller gave 9%, changed to 16 lbs. gave 12%, due to less grip and probably long fibres taken out.

To find Percentage of Waste.—Have doffer comb at

the bottom of its swing, now remove all waste at the back up to the doffer comb. Break the sliver at the draw-box calender rollers. Work the machine for, say, 40 nips, leaving the doffer comb at its lowest point. Now weigh respectively the sliver and the waste made. The two added will equal the original cotton, and the waste will represent a percentage of this total. For instance—

Good sliver = 60 grains
Waste = 15 ,,

Total cotton = 75 grains.

If 75 grains of lap have 15 grains of waste,

Then 100 grains of lap have $\frac{15 \times 100}{75}$ grains of waste,

$\therefore \frac{15 \times 100}{75} = 20$ per cent of waste taken out.

CHAPTER III

FLY-FRAMES

Object of Fly-Frames.—Hitherto, the processes described here have all been directed towards obtaining a uniform strand of cotton, free from impurities, and whose component fibres approach within a reasonable degree of equality in their length. The actions that have been employed to produce this result are Beating, Combing, Drawing, and Doubling, and the cotton in being subjected thereto has been reduced from an irregular mass of tangled fibres to, comparatively speaking, a condition of regularity and uniformity.

The next process is one primarily intended simply as a continuation of the Drawing process, with or without the combination of Doubling. Owing, however, to the extreme delicacy of the sliver, any further reduction of its diameter would make it so weak as to practically prevent its further treatment, unless such reduction were accompanied by some action which strengthened it, so that it could withstand the strains to which it would be subjected when undergoing the next steps in the process. In addition to this, we can easily understand, from what we have seen of the coiler, that the use of this for coiling a much finer roving or sliver would be a very clumsy

method, and consequently a slight twist is given to the reduced sliver, and it is then wound upon a bobbin. The small amount of twist given to the attenuated and extremely loose sliver is sufficient to give it the necessary strength to enable it to be built up in the form of a bobbin, in which condition it is very convenient for further treatment. The drawing-out or reduction of the sliver, from the diameter as it exists when passing through the drawing frame to a diameter suitable for the process of spinning, is so great, and results in such a weak sliver or roving, that a very delicate and gradual operation must be exercised. The steps, by means of which the reduction is made, depend upon the degree of fineness required in the resultant yarn, and consequently they vary in number.

The machines used for effecting the attenuation of the sliver are called by the different names of **Fly-Frames, Roving Frames,** and **Speeders:** and according as one or more of these are used, we get specific names for the machines in each step. For instance, the first fly-frame used after the draw-frame is called a **Slubbing Frame;** following this is the **Intermediate Frame,** and then the **Roving Frame;** after which (for fine spinning) a finer roving frame is used, called a **Jack Frame.** The order of these machines for their several purposes will be seen on referring back to p. 39, vol. ii., where their sequence was shown for various numbers; and it will also be noticed that as the numbers or counts increase, so do the number of sets or passages of fly-frames. The objects of each machine are exactly the same, and so for all practical purposes their structure and mechanism are alike, the only difference being in the strength and dimensions of the various parts.

The necessity that arises at this stage in the building

of the roving or sliver in the form of a bobbin, also introduces in its wake complications of mechanism for automatically performing it, and these give to cotton machinery, from the mechanical point of view, one of its greatest sources of interest.

The bobbin is made by winding the sliver round a wooden cylinder in layers until a suitable diameter is obtained. When finished it has the appearance of a cylinder with its ends tapered, in which condition it is the more readily, and with the least possibility of injury to itself, taken from one machine to another. The various problems connected with the building of the bobbin will be dealt with as thoroughly as possible as the description proceeds. It is sufficient at this stage to mention that the placing of layer upon layer of roving on the bobbin necessitates a varying speed being given to it in the fly-frames, the delivery of sliver during the process being constant. There is also a variation in the length of transverse, to give the tapered character to the bobbin. These two motions present some very ingenious and mechanical problems, which it is advisable should be thoroughly understood, if more than a mere superficial knowledge of the subject is to be obtained.

In regard to the twist put into the roving, it will be found that twisting is an inevitable consequence of this mode of forming a bobbin by means of a flyer; but arrangements are made in the machine whereby the amount—within certain limits—can be carefully regulated. For all practical purposes the twist or turns per inch is largely a question of experience, and depends upon several factors, which must always be taken into account when deciding upon this important point. It is, however, never more than might be correctly described as a "slight twist"; for

it must be clearly understood that the merest excess of twist in the roving would prevent any further drawing in the following machines. From this we can readily comprehend that, although the twisting is taken advantage of for giving cohesion to the fibres during the winding operation, the ultimate purpose of the yarn must be kept in view, and the twists must also be arranged so that the effectiveness of any future drawing action will not be destroyed. In following the passage of the cotton through the several fly-frames it will be remarked that the reduction of the sliver takes place gradually, a little at each frame. The exact amount of the draft, of course, depends upon the cotton used, and also upon the numbers to be spun, but the accompanying table will convey an idea of the usual course adopted in most mills:—

DRAFTS FOR INDIAN AND AMERICAN COTTON.

	Draft.
Slubbing Frame	4 to 5
Intermediate Frame	5 ,, 6
Roving Frame	$5\frac{1}{2}$,, $6\frac{1}{2}$

DRAFTS FOR EGYPTIAN AND SEA ISLAND COTTON.

	Draft.
Slubbing Frame	5 to $5\frac{1}{2}$
Intermediate Frame	$5\frac{1}{2}$,, $6\frac{1}{2}$
Roving Frame	$6\frac{1}{2}$,, 8
Jack Frame	$5\frac{1}{2}$ upwards

There are many variations in drafts introduced in order to obtain identical results, and this is so true that probably no two men would use the same drafts in spinning similar classes of yarn. The reason for this is almost apparent: the number of machines through which the cotton must pass, readily permits a give-and-take policy in the arrangements of the drafts, and many men would alter the drafts of one or two machines only, instead of making a change on all the machines—provided, of course, there was nothing

excessive in such a method. It is, however, always advisable to let each machine do its own share in the work of making the roving finer: this will mean more time and labour in making changes, but better results are certain to be obtained by the extra trouble involved. It has been remarked that very little difference exists between the four passages of fly-frames, and what difference does exist is caused by alterations in the diameter of the full bobbins and in their lengths. In the slubber the bobbins are large and long; they get smaller as the roving is made finer, until in the Jack we have a bobbin with only one-quarter to one-fifth the amount of roving on it. The following table presents the usual practice in regard to this feature, but it must be understood that slight variations exist on either side of the dimensions given :—

COTTON.	SLUBBER.		INTERMEDIATE		ROVING.		JACK.	
	Dia.	Lift.	Dia.	Lift.	Dia.	Lift.	Dia.	Lift.
	in.	in.	in.	in.	in.	in.	in.	in.
Indian and Low American . .	$5\frac{3}{4}$	10	$4\frac{1}{2}$	10	$3\frac{1}{2}$	7	...	..
American and Low Egyptian .	$5\frac{1}{2}$	10	$4\frac{1}{2}$	10	$3\frac{1}{2}$	7	..	.
Good Egyptian and Sea Islands	$5\frac{1}{2}$	10	$4\frac{1}{2}$	10	$3\frac{1}{2}$	8	...	..
American . . .	...	...	...	...	...	..	$2\frac{3}{4}$	7
Egyptian . . .	...	...	...	..	...	...	$2\frac{3}{4}$	7
Sea Island . .	...	...	...	...	...	...	$2\frac{1}{2}$	7

Description of Fly-Frame.—In the accompanying sketch (Fig. 63) a transverse section through a fly-frame is given. As will be seen, it is not complete, but a sufficient portion of the machine is shown to enable its essential

features to be pointed out and explained; a full detailed examination of its actions will afterwards be made, and, as

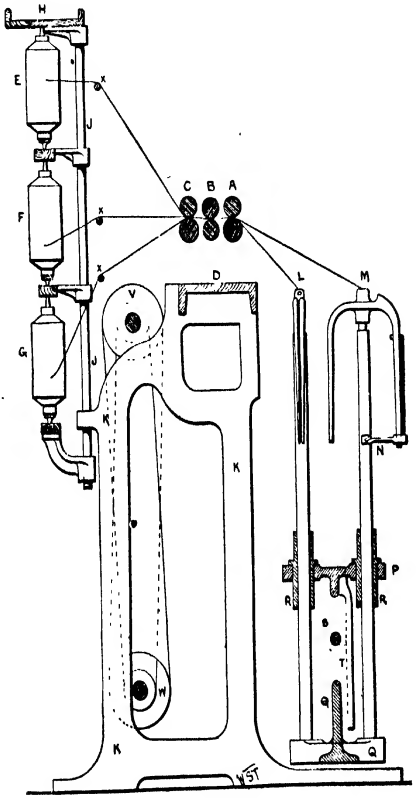


FIG. 63.

far as possible, illustrated by numerous drawings and diagrams.

On reference to the drawing (Fig. 63) it will be noticed that the sliver is fed to the rollers at the back, from bobbins, placed in a suitable structure called a creel. (This name is

given to almost all arrangements in cotton machinery by which bobbins are carried.) It must, however, be pointed out that in the slubbing frame this creel is not necessary, because in that case the cans from the drawing frames stand behind the machine, and their slivers are taken over a slowly revolving tin drum and passed on to the rollers. When bobbins are formed, a creel becomes requisite for carrying them, and its exact form varies according to the number of bobbins it has to accommodate, and also the number of heights in which it is convenient to make it. In the sketch a single row is used, and it is made in three heights. The full bobbins are taken from the previous machine, and placed on wooden skewers; a shoulder on the skewer forms a resting-place for the bobbin, so that they are prevented from touching the long wooden rails, which go the full length of the machine, and which constitute the chief features of the creel. These skewers are pointed at each end. The upper portion enters the rail, and rests in a hole protected by a small iron ring to reduce friction, whilst the lower end rests upon a small recessed cup-shaped porcelain step, well glazed, so as to offer as little resistance as possible to the revolution of the bobbin as the sliver is drawn from it. As a rule, in modern mills, the rails of the creel are really made of long lengths of thin angle iron, with the wooden part screwed to them on their under side. This gives a much stronger creel, and one that is practically indestructible. The rails are carried by brackets fixed to upright rods J, which are in their turn securely fastened to the spring pieces of the machine. This arrangement of the creel enables the distance apart of the rails to be readily adjusted. The top of the creel is made so that a stock of full bobbins can be placed there ready for immediate use.

The rovings are taken from the bobbins E, F, and G, and passing over the guide rods X are led to the three lines of rollers A, B, and C. In going through these they are subject to a drawing action the same as in the draw-frame, and to this extent it is simply a continuation of that process. The amount of this draft for general purposes has already been given, see p. 120.

We are now in a position to see the need for the introduction of twist into the roving. The strain upon the sliver as the back roller takes it forward is considerable, when we take into account that it has to pull round the full bobbins in order to unwind itself, and so an additional cohesive power is given to it by twisting, in which the fibres are rather more firmly bound together, but not sufficiently so to interfere with the further drawing to which it must submit in the next operation.

The drawn-out sliver or roving is taken from the rollers and threaded through the flyers L M, and wound upon bobbins which loosely fit the long spindles that carry the flyers. The bobbins are all driven separately and independently of the spindles, whilst the spindles also are individually driven. The spindle consists of a long steel rod, whose diameter varies from $\frac{7}{8}$ in. in slubbing frames to $\frac{9}{16}$ in. in jack or fine roving frames. Its length also varies according to the machine. In consequence of the speed at which it revolves, it requires to be well supported in suitable bearings, so as to prevent vibration and reduce friction as much as possible. It is, therefore, carried in a footstep bearing at Q, and in a bolster bearing at P. The bearings at these points are made as long as possible by means of the collars R R firmly fixed to the top rail P. These collars are generally made in two lengths, and hence they are usually known by the terms of "long" and

"short" collars. The top rail P has resting upon it all the bobbins of the machine. Since the spindles and flyers are stationary so far as vertical movement is concerned, the bobbins must be given this motion in order to have wound upon them the roving which passes through the flyer. With this object in view, the rail P is given a perpendicular movement, which constitutes the lift or traverse of the machine, and defines the length of the bobbin. It receives the motion through a rack T and wheel S, the rack being fastened to the rail and the wheel obtaining its movement through suitable gearing from the driving shaft.

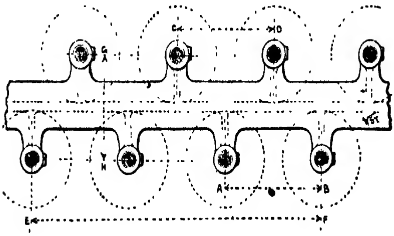


FIG. 64

Arrangement of Spindles.—All fly-frames are made with two rows of spindles, so disposed as to economise space and yet obtain a maximum number of spindles in a given length. Fig. 64 is given as an illustration of this, and from it we see that they are arranged in a zig-zag order—in many cases regularly so, but in other makes of machines the back row is not placed exactly midway between the centres in the front row, but a little to one side, the object being to facilitate doffing, etc. The "**space**" of the spindles is the distance from the centre of one to the centre of the next, as at A B or C D, whether we take the front or back row for the measurement. In many

cases, however, the word "space" is replaced by the word "**gauge**," and instead of expressing the space of the spindles the machine is spoken of as having a certain "gauge." This to a certain extent is an advantage, because both rows of spindles are taken into account when the number or length of the machine is required, whilst in the first case only one row is expressed, and so it is necessary to double or half, as the case may be. In the sketch the "gauge" of the spindles would be denoted by saying that there are six spindles in the distance E F. This measurement, it will be seen, includes three spindles in each row.

The following will show the two methods of denoting the space of spindle:—

Distance of spindle from centre to centre	in. $5\frac{1}{2}$	in. $5\frac{3}{4}$	in. 6	in. $6\frac{1}{4}$	in. $6\frac{1}{2}$	in. 7
Or equal to 6 spindles in	$16\frac{1}{2}$	$17\frac{1}{4}$	18	$18\frac{3}{4}$	$19\frac{1}{2}$	21

Roller Stands.—A general view of the roller stand and the method of setting the rollers is given in the accompanying drawing (Fig. 65). On reference to it, it will be noted that the stand itself is a fixture on the roller beam N, and that it carries the front roller D. The other two lines of rollers are carried by separate bearings E and F, which are so arranged on the main stand that their distance from each other can be adjusted so as to suit various lengths of staple, thus giving every facility for setting; after which they are readily fixed in position by means of the set screw. The recess G is occupied by the traverse rod, which moves the roving to and fro along the roller with the object of preventing an undue wear of the leather on the top roller. The top rollers—made either with a single or double boss, and also with or without loose bosses—are covered with leather in the usual way, and carried by an arrangement of cap bars, these latter not being used as

bearings, but simply as side supports for the ends of the rollers. They are made so as to enable the rollers to be readily taken out, and also so that any given set of bars may be bodily removed or turned over out of the way of the bottom rollers. It was formerly the practice to make the cap bars of cast-iron, but difficulties were experienced in several directions when so made, there being irregularities in the spaces, owing to moulding and casting, a slight damage necessitating an entirely new cap bar; there was

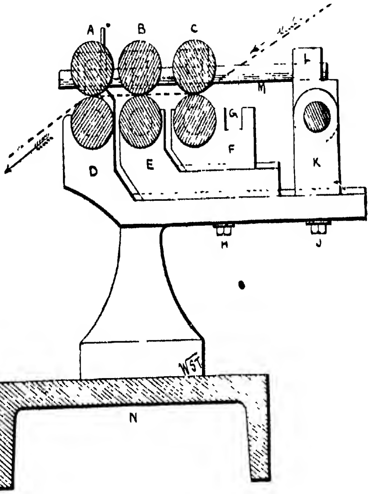


FIG. 65.

also a lack of simplicity in the adjustment of the slides for the different rollers, and, owing to the strain caused by screwing the loose parts together, various other parts were twisted out of truth. Very great care in the making can obviate some of these faults, and irregularities are the more easily rectified by means of milling machines, so that some makers still adhere to this method of making the cap

bars. Another system, now extensively followed, is that shown in Figs. 65 and 66. Here a support K is fixed to the roller stand, and carries a shaft or stud F, and on this shaft, at the necessary intervals, are fixed small brackets E (Fig. 66). These carry a long finger D of a pentagonal section (see H), and on it are threaded the cap nebs, A, B, and C, which form the supports for the top rollers. The hole through the nebs is similar to the section of the finger, and consequently they are prevented from turning, and, in addition, no side strain is introduced, because they are firmly screwed in position by set-screws bearing on a perfectly flat surface of the finger. The projections on A serve the purpose of a rest for the flat or clearers on the

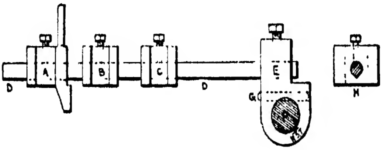


FIG. 66

upper part, and, on the lower one, adjust the centre vertically for the top rollers. As it may easily happen that carelessness or other causes might allow the finger or nebs to fall on the fluted rollers, precautions are necessary, and a slight recess is cut in F, and a tapered pin driven into the bracket E, this pin effectively preventing any twisting of the bracket, and also holding it securely in position.

Roller Weights.—A front view of the rollers and stands is given in Fig. 67. The sketch shows four spindles to a box, *i.e.* between two roller stands rovings are delivered, which supply four spindles. Double-boss top rollers are used, and the cap bars would be placed to support the pivoted ends at L M, J K, and N P. The weights applied to give the required pressure between the rollers would in

each case hang from G H. These weights, like many other details of cotton machinery, vary in their amount, but the following may be taken as representing the usual practice:—

	Front. lbs.	Middle. lbs.	Back. lbs.
Slubbing Frame	18	14	10
Intermediate Frame	14	10	8
Roving Frame, single boss	10	8	6
,, ,, double boss	18	14	12

In Roving and Jack Frames it is usual to have the back and middle rollers self-weighted, *i.e.* the weight of the

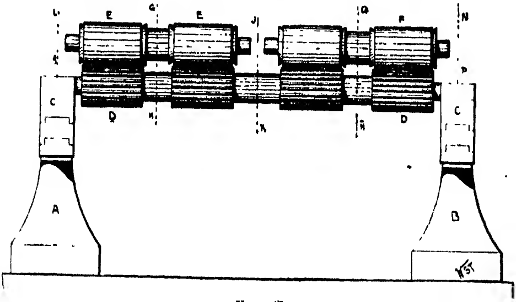


FIG. 67.

rollers themselves is sufficient for the purpose, in which case the back roller is made much larger in diameter, as will be seen on reference to the next sketch.

Diameter and setting of Rollers.—In this diagram (Fig. 68) a representation is given of the usual diameters, and the distance apart of fly-frame rollers for various classes of cotton; but it must be impressed upon the reader that no hard and fast line is to be drawn in respect to the dimensions given, and it will always be necessary to exercise judgment upon the special characteristics and staple of the cotton worked.[1]

[1] See Vol. III. for fuller details of rollers, etc.

A	Indian cotton	Slubbing Frame.
B	American cotton	
C	Egyptian and Sea Island cotton	
D	Indian cotton	Intermediate Frame.
E	American cotton	
F	Egyptian and Sea Island cotton	
G	American cotton	Roving and Jack Frame.
H	Egyptian and Sea Island cotton	

NOTE.—In the jack frame the distances apart of the rollers will be slightly greater than in the roving frame. It must also be observed that the top roller diameters are for the rollers when uncovered.

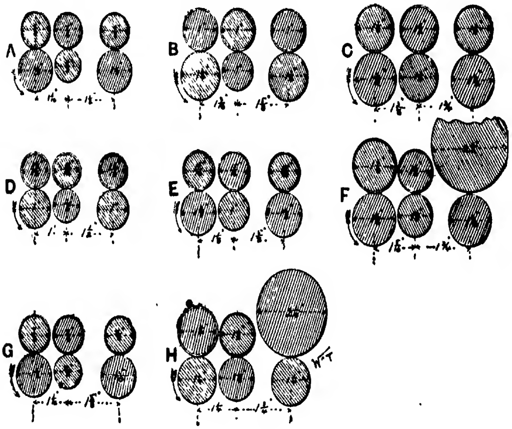


FIG. 68.

A general idea of the number of flutes in fly-frame rollers may be obtained from the following:—

$1\frac{1}{8}$ in. dia. $=54$. $1\frac{1}{4}$ in. dia. $=60$. $1\frac{3}{8}$ in. dia. $=65$.

Twisting.—It has been remarked that directly the roving emerges from the front roller it undergoes a twisting operation—a somewhat necessary effect of winding it upon a bobbin by means of a flyer. We can now examine this action in detail. When it is desired to put twist into any arrangement of fibres, etc., the essential

condition is that one end must be held while the other is twisted. This statement is so expressed because in cotton spinning machinery the definition fits in with actual practice. A better method of defining how twist is produced may be by stating that one end of the substance must be revolved round its axis at a quicker rate than the other end, and in the same or the opposite direction. Even this definition might be simplified to some minds by saying that the angular velocities of each end must vary, when measured in the same direction, in order to produce twist or to cause an intertwining of the component parts of the substance. In the example of the flyer, this condition is carried out in a very simple manner. Figs. 69 and 70 are presented to illustrate the description of its form and action. The spindle upon which the flyer is placed is a long steel rod carried by a footstep and a bolster. At the footstep end it is slightly reduced in diameter, as shown in Fig. 71, and its bearing is usually a recess fitted with a brass bottom; or it can be made self-lubricating with a loose brass bottom part. In the sketch, however, an improvement is shown that enables the oiling of the spindle footsteps to be done very effectively, and with a minimum of trouble, and at the same time a reservoir keeps the bearing well lubricated. The spindle is grooved for a short distance above the point where the small bevel is fixed, and a slight recess is cut in the upper part of the bevel wheel. By oiling at this point the oil descends by the groove to the reservoir, and in this way the necessity of going through the trouble of lifting the spindles is dispensed with. As shown in the drawing, it is well-nigh impossible for dirt, etc., to enter the oil-cup.

Collars.—The bolster bearing is also a very important matter, and consists of special bearings, called **collars,**

securely fixed to the spindle rail. Either long or short collars are used, and these are generally fastened as shown

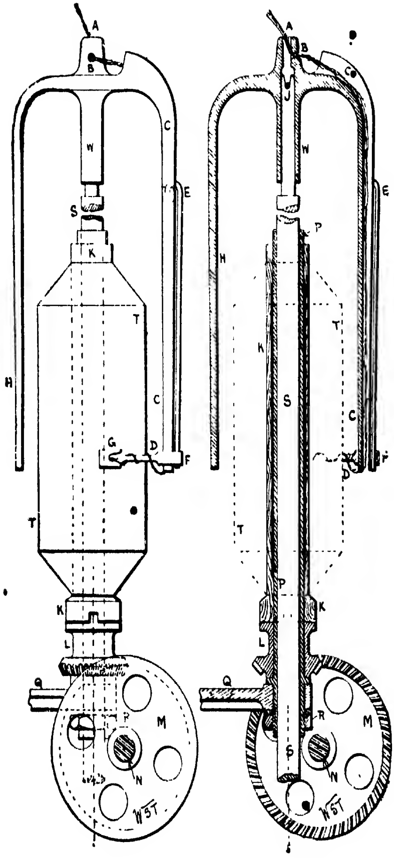


Fig. 69. Fig. 70.

in Fig. 70. The lower portion of the collar fits a hole bored in the rail, and, by means of a shoulder, is bedded very truly to a milled facing provided for that purpose.

It is then firmly fastened on its under side by a nut R, and frequently by a set-screw at the side of the snug. A long collar is shown in the drawing, but much difference of opinion prevails as to the merits or demerits of the two kinds. Each, however, has its advantages, those of the short collar, being, of course, obvious. It is made of just sufficient length to serve the purpose for which it is intended, viz. to support the spindle; but when we consider the great length of spindle above the bearing, and also the flyer, which is practically unbalanced throughout the whole

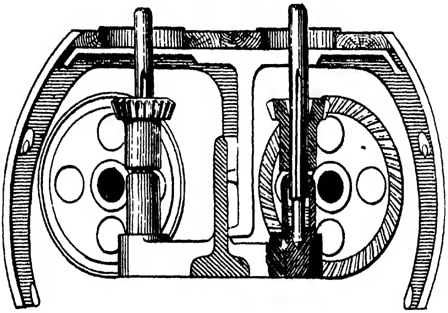


FIG. 71.

of the time it is building the bobbin, it will readily be seen that it is advisable to give more support than is obtained by the short collar, especially for high speed. Practical difficulties, however, used to stand in the way of their use: the correct boring of a long collar was no easy matter, and it was found that, owing to this irregularity, friction was developed, and more power was required to drive the frame. The bearing points were generally at the top and bottom of the collar, the intermediate part being barrelled or recessed out. Modern tools have now overcome these difficulties, and a perfect long collar can easily

be made. The recess is also dispensed with by several makers, as dirt and fly accumulate on the inside and interfere with correct working. The spindle thus bears the whole length of the collar. Another disadvantage of the long collar is the fact that a large bobbin is necessary, owing to the larger hole required to fit over the collar, this, of course, causing extra weight.

Flyer and Presser.—The flyer fits upon a reduced portion of the spindle by means of a socket, a recess being cut across the top, into which drops a pin J, inserted in the boss part of the flyer (Fig. 70). In this way the two parts are made one, so far as revolving together is concerned. The roving is inserted in a hole A in the flyer top, and passed through a small opening B in the side. The mere fact of passing the roving through this last opening gives to the flyer its ability to produce twist, for B is clearly out of the centre of the spindle, and describes a small circle as the flyer revolves. The other end of the roving is held by the roller; every revolution of the spindle naturally gives a twist, and, according to the relative speeds of the flyer and front roller, we get varying degrees of twist—generally expressed as **twists per inch.** The length of the bobbin to be built, and the weak nature of the roving, necessitate that it should be guided on the bobbin at a point much lower than where it emerges from the hole B, and we thus get a long arm, made hollow, down which the roving is passed. From the bottom of this arm it is wound round, and then threaded through the eye of a projecting arm loosely attached to the flyer leg, and from this it is drawn forward by the bobbin. The projecting piece D is termed a **presser**, its function being to give as light pressure to the roving on the bobbin in order to obtain a firmer result. It is specially arranged

to do this, and reference will now be made to the method adopted; but it ought to be first remarked that, in order to balance the arm C, another arm H is made on the opposite side, of such dimensions that its weight balances that of the hollow arm.

The Presser and its Functions.—The "presser" is composed of two parts - one is the projection called the paddle, or presser, and the other a thick wire rod running up the side of the leg, and centered at E, the two being

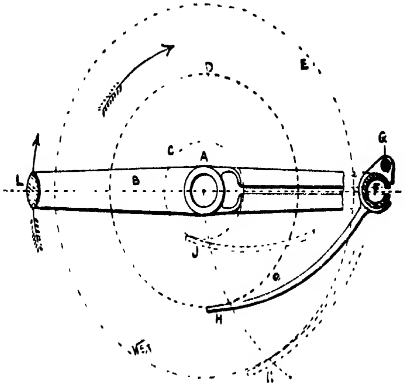


FIG. 72.

connected at F. The paddle D is made to fit loosely over the flyer leg, and as E is capable of swivelling from its centre, which is practically that of the arm C, it is clearly seen that any movement of the wire rod will be transferred to the paddle. To illustrate this further, a plan view of a flyer is given in Fig. 72 G is the rod running up the side of the leg, H is the paddle working round the leg F as a centre; G also, for all practical purposes, works round the same centre. The weight of G is greater than that of the paddle, and, in addition, it revolves at a farther distance

from the centre of the spindle, so that it has a greater tendency to fly away from that centre. It is free to do so, but is guided by its connection to F; the centrifugal force thus tending to move G outwards being resisted by the bobbin, which prevents the other end of the paddle moving inwards. A pressure is consequently set up at H, which causes H to press against the roving on the bobbin, and we therefore get a more solid bobbin.

As made in our machine shops, the flyer is perfectly

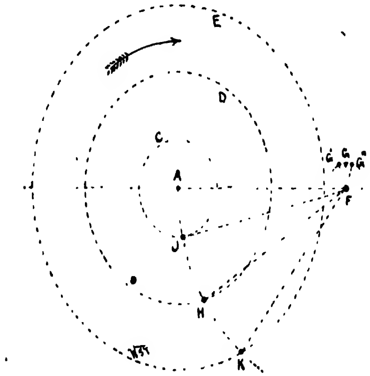


FIG. 73.

balanced when the presser occupies the position shown at H in Fig. 72; but this is the only place where such a condition exists. The presser, being a movable piece that is continually changing its position, disturbs the balance directly it assumes any other position than that shown.

A diagram is given in Fig. 73 from which the foregoing description may be supplemented, and the unbalancing character of the presser explained. C is the bare bobbin, D its middle diameter, and E the full diameter. The flyer leg is marked at F, and the paddle, in its several positions,

at J F, H F, and K F, the respective positions of the wire rod being shown at G^1, G, and G^{11}. When the paddle is pressing on the bare bobbin at J, the weight is at G^{11}, at its farthest distance from A. In this position it is exerting its greatest tendency to fly outwards, and, as a consequence, the paddle will press the more firmly at J. As the bobbin is building the increasing layers will move the paddle outwards, this action, of course, bringing G nearer to the centre A, in which position its surface velocity is not so high, and therefore it exerts less force to fly outwards, so that the pressure on the bobbin at K is less than at H or J. It must not be forgotten, also, that the paddle itself has a tendency to fly away from the bobbin owing to centrifugal force, and is only prevented from doing so by the superior weight and the greater distance of G from the centre A. This tendency on the part of the paddle increases as the bobbin fills, so that as the centrifugal force of G decreases, the same force in the paddle increases, and both these result in a diminished pressure of the presser as the bobbin fills. By altering the relative weights of the wire rod G and the paddle, almost any degree of firmness or softness can be obtained on the bobbin.

It will readily be comprehended from the above reasoning that this altering of the centre of gravity of the presser brings a slightly additional weight nearer or farther away from the centre, and so disturbs the balance of the flyer. With a single pressure this is inevitable, and as nothing very serious results from it, it is almost ignored. Some time ago, however, an attempt was made to obtain a perfect balance throughout the building of the bobbin by the introduction of double pressers, one on each arm, but they are never made at present.

The different surface velocities of the bobbin and the

flyer cause a rubbing action between the presser and the roving on the bobbin, and everything is done by careful workmanship to neutralise the evil effects that may arise from this cause. In a double flyer this evil would be twofold.

Flyer Leg.—The slot in the flyer leg is usually made straight, as shown at A in Fig. 74, but for high speeds and fine rovings there is an advantage in making it with what is called "winding" in it--that is, with a slightly curved form, as at B. This prevents the centrifugal force sending the roving through the slot. A flyer, it must be said, is one of the most highly finished appliances in cotton machinery, and a very large number of operations have to be gone through before a finished article is obtained. It must be perfectly smooth all over, and made of the finest material, to prevent accumulations of fly, etc., which would be fatal to good yarn.

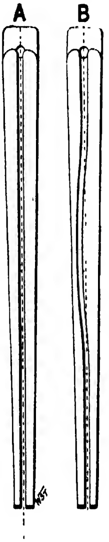


FIG. 74.

Previous sketches will convey some idea of how the driving of the spindles and bobbins is performed, but a complete view is given in the following sketch (Fig. 75). A is the bobbin wheel on the driving shaft (but not driven direct from it); the two rows of bobbins are connected by a pair of wheels C and D, which necessitate the arrangement of the bevels as shown at E F and H G; the spindles are driven direct from the driving shaft through the wheel N, which is fixed to it, the necessary gearing being shown in the latter case simply by dotted lines.

A description has been given of the flyer and the bobbin, with their driving arrangements, sufficient to enable the

following explanation to be made of the method adopted in placing the roving upon the wooden cylinder that forms the foundation of the bobbin. There is always a real difficulty experienced by students in comprehending the proper meaning of the terms **bobbin leading** and **flyer**

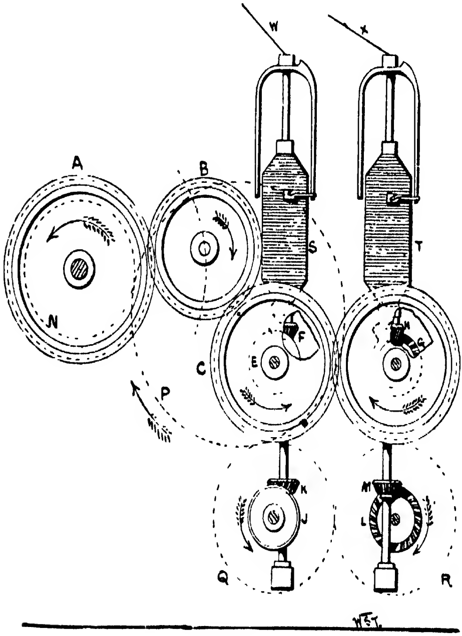


FIG. 75

leading; and although a general statement of their purpose can easily be made, and, perhaps, as readily understood, yet the analysis of their operations is not so satisfactorily apprehended. An attempt will therefore now be made to present the subject in as clear a light as possible, and the diagrams accompanying the description will materially help towards making it intelligible.

Principle of Winding.—As already explained, the roving comes from the rollers at a continuous and regular rate, which is dependent upon their surface speed or revolution. The problem to be solved, therefore, is how to place this roving upon the bobbin at exactly the same rate as it is delivered from the rollers. Two methods have been adopted: one, in which the flyer wraps the roving upon the bobbin; and the other, in which the bobbin winds it round itself. These give rise to the two terms mentioned above, but before indicating the present practice, an examination will be made of the principles upon which "winding," as it is called, depends.

A simple illustration will be given in the first instance on the effect of the relative velocities of two points;—it is upon this feature that the winding has its basis. In Fig. 76 (top left-hand corner), A and B represent two points, connected together by some material that can be "paid out" if the points separate. If these points are caused to move in the direction of the arrows, at equal velocities, they will arrive at C and D without altering their relative positions, so that the material connecting them has not been influenced in any way. If, however, only one point moves, as at E, the material must be paid out in order to keep the points connected, the amount being denoted by the line F, G. This length, of course, would be doubled if the point F, instead of being fixed, were caused to move in the opposite direction. A modification of this case is shown in H and I, where H moves to J at the same time as I moves to K, only half the distance separating them, which denotes the amount paid out; it would give the same result if the relative movements of H and I were reversed.

Another illustration, approaching more nearly to the conditions of the special case of the fly-frame, is represented

by the first five diagrams, and shows the effect when a circular movement is made by the points instead of a horizontal one, as in the preceding case: A and B are two points, connected as before with material capable of being

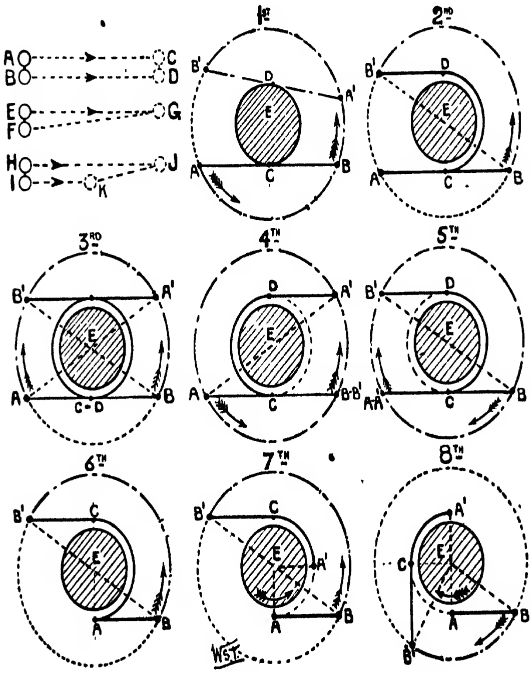


Fig. 76.

paid out by one or the other or both—but for simplicity say B. Each point moves round the centre, and we require to know the effect of the respective velocities of A and B upon the material as they move round the centre. In the first case they move at equal velocities in the same direction, so that on reaching the position A^1 B^1 no change

in the line joining them has taken place; it remains exactly the same length as before. In the second diagram, A remains fixed while B moves, and it is readily seen that B no sooner begins to move than the material must be given up in order to maintain its tension, so that when B arrives at B^1 the amount of this material is represented by the semicircle C D. By causing A to move in the direction opposite to B (as in case 3), half a revolution of each would cause a complete turn of the material to be made round E, half of which would be wrapped round by A, and the other half by B.

In Diagrams 4 and 5 a modication of the first two diagrams is given, both points, A and B, being allowed to move in the same direction, but at different velocities. By reference to Diagram 4, B is supposed to make a complete revolution at the same time as A makes half a revolution to A^1; this has the result of winding on half a revolution of the material on E. It will be seen that B's movement would give a complete turn; but since A moves in the same direction, half of it only will be laid on the centre E. Diagram 5 represents the reverse of this, though producing the same results: A is made to go through one revolution during the time that B makes half a revolution. The peculiarity to notice here is the direction of motion compared with that shown in Diagram 4: this is a necessity if the tension of the material between the two points is to be maintained, for if the direction were reversed in No. 5, the superior speed of A over B would instantly cause the material to go slack, and the first condition of winding would be destroyed. There is one way of keeping the same direction of rotation in the two cases, and that is by reversing the positions of A and B. This would make No. 5 case almost similar then to No. 4, with the exception

that the material is given up from the opposite side of the circle that forms the path of the movement of the points.

From this illustration a step farther may be taken, of a more practical character, and directly connected with the actual effect of winding. We have seen from the examples given that a material can be wound round a centre bobbin when two points through which it passes are revolving at different speeds. By giving a diagrammatic view of the conditions existing in the fly-frame this may be fully exemplified and made obvious. For this purpose the 6th, 7th, and 8th diagrams have been prepared, the reference letters corresponding in each case: E is the centre bobbin upon which the roving is wound; B is the flyer through which the roving passes to the bobbin; its path is shown by the dotted outer circle; A is the point where the roving is laid on the bobbin.

In Diagram 6 it is assumed that the bobbin is stationary and the flyer B revolving. When B has gone through half a revolution it will naturally have wrapped upon the bobbin a length of roving equal to half of the circumference of E, as shown by the line A C. Now this is a perfectly natural way of placing the roving upon a bobbin as far as a single layer is concerned; but practical considerations in respect of placing a number of layers upon it necessitate a modification of this case, in which the bobbin itself is given a motion, but in its degree varying from that of the flyer. Two cases are given: one (No. 7) in which the flyer moves more quickly than the bobbin, technically called "flyer leading"; and the other case (No. 8) in which the speed of the bobbin is much the quicker—from which we get the term "bobbin leading."

On reference to Diagram 7, if the flyer B revolves through half a circle to B^1 while the point A on the bobbin

only goes a quarter of a revolution to A^1, it is obvious that the two points A and B will separate to the extent of the quarter of the circle A^1 C; in other words, since the tension remains constant this length of roving has been drawn through the flyer leg B and wound upon the bobbin. Now take the case of diagram 8: here A and B occupy the same position as in No. 7, but the bobbin is assumed to go half a revolution in the same time as the flyer B goes a quarter of a turn to B^1. The first thing to notice is the direction of movement: it is clearly impossible, as they are at present arranged, for them to move in any other direction; otherwise, since A moves quicker than B, the roving would go slack between the two points. It is therefore necessary in bobbin-leading, as compared with flyer-leading, either to change the direction of driving or reverse the position of the presser of the flyer which corresponds to the line A B.

In respect of the winding, it will be seen that the point A moves half a turn to A^1; at the same time the flyer B has gone a quarter of a turn to B^1, which clearly causes a separation to take place between the two points A and B to the extent of the portion of the circle A^1 C. This length has been drawn from the flyer owing to the superior speed of A, and for the same reason it winds it upon itself, as shown. At the present time all fly-frames are made with **bobbin-leading,** as this system is found to possess superior practical advantages over the **flyer-leading.** The reason for this adoption will be given subsequently when dealing with the problem of building the bobbin.

Flyer leading.—If the foregoing description has been closely followed it will have prepared the reader for the next step explanatory of the process of building the bobbin. The two diagrams, Figs. 77 and 78, have been prepared in order to elucidate it, and in connection therewith a little

recapitulation will be necessary. Fig. 77 represents the case of the "flyer leading"; in it the flyer B is shown as having moved through half a revolution to B^1 in the same time as the bobbin E has revolved one quarter of a revolution to A^1. This results, as already shown, in the flyer winding on the bobbin a length of roving equal to a quarter the circumference of the bare bobbin, represented by the thick line A^1 C. The relative velocities of the flyer and bobbin will keep the same until the first layer is completed, but when we come to wind the next layer

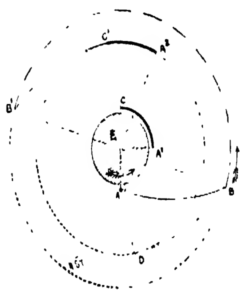


FIG. 77.

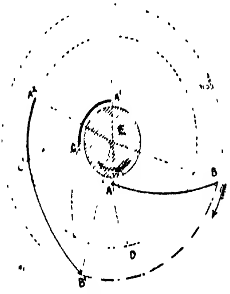


FIG. 78

upon the first one, it must be done on a larger diameter; —and this fact introduces a new order of conditions, which will now be dealt with, and which brings us face to face with the real problem of winding. As a preliminary, two conditions must be remembered, viz. the flyer revolves at a constant speed, and the roving is delivered regularly from the rollers whatever diameter the bobbin may be. The conclusion to be drawn from this latter fact is, that the bobbin must run at such a speed as to wind on exactly the same amount of roving as is delivered from the front roller, whether it be full or empty. The effect of winding on a larger diameter will now be considered, and in order

to emphasise the matter the difference between the empty and the full bobbin will be taken as an illustration. On the empty bobbin, C A^1, Fig. 77, is wound on during the same time as the flyer B moves through half and the bobbin E through a quarter of a revolution. Now, on the full bobbin, this length C A^1 must be wound on in exactly the same time as on E; the position of the presser (along which the roving travels) has moved from B C to B C^1 (or from B A to B D): C^1 is therefore the point of contact where the roving enters on the full bobbin, and from here to A^2 (shown by a thick line) is represented a length C^1 A^2, equal to C A^1. Whilst the flyer has therefore moved half a revolution, the bobbin must have gone through a much larger angle than a quarter of a revolution, as it did when the bobbin was empty: in other words, it has had to increase its speed from a quarter to almost half a revolution, the angle D E A^2 representing the exact amount. From this it is seen that when the flyer leads, the bobbin, starting at a certain speed when empty, must gradually increase its rate of revolution as it gets larger in diameter.

Bobbin leading.—The case of the "bobbin leading" will now be taken, Fig. 78 being used for reference. As before observed, the bobbin E has the quickest speed, and while it goes through half a revolution, from A to A^1, the flyer moves through a quarter of a turn, from B to B^1, with the result that the empty bobbin winds on itself a length of roving equal to C A^1. As the bobbin fills, the presser will move outwards from A to D, and when the flyer makes its quarter of a revolution it will occupy the position B^1 C^1. From this point a length of roving C^1 A^2 is shown on the full bobbin equal to the same length C A^1 on the empty bobbin. On the empty bobbin it required

half a revolution to wind this length on, but on the full bobbin it will be seen that only a little over quarter of a revolution is required, as shown by the angle D E A^2. This means that as the bobbin fills it must gradually decrease in speed from what it started with as an empty bobbin.

To sum up the questions that have just been discussed: we may say that with the "flyer leading" the flyer revolves quicker than the bobbin, and, as the bobbin increases in diameter, its speed must increase in order to have wound on it the same length as on the smaller diameter. When the "bobbin leads," the bobbin revolves at a quicker speed than the flyer, and as it increases in diameter it must decrease in speed; its direction of revolution is opposite to that when the flyer leads, or else the flyer must be on the opposite hand.

At the present time the "flyer leading" has fallen into disuse. Several reasons are assigned for this; one objection is the increase in speed necessary for the bobbin as it enlarges and gets heavier; another is the fact that through the indirect driving of the bobbin by means of a strap on the cone drums the flyer is caused to start a little earlier than the bobbin, which produces a strain on the roving, and results in frequent breakages. This evil is traceable also to the general gearing, and is said to be the result of more backlash existing in the larger number of wheels used in the driving of the bobbin than in the driving of the flyer. Each may be accredited with its share of the condemnation of this principle, and although the same conditions exist, yet they do not appear as evils when the "bobbin leads," for, instead of the late start of the bobbin resulting in a strain and breakage, the roving is slackened a little; this, however, is quickly taken up in

the course of a revolution or so as the strap and wheels drop into their working positions. A simple illustration will show the necessity for slowing the bobbin as it fills. It is as follows:—Suppose a bobbin one inch in diameter turns once round; in so doing it will wind on itself 3·1416 in. of roving. If it be now enlarged to 3 in. diameter one revolution will wind on 9·4248 in., so that for the larger diameter to wind on the same amount as the smaller one it must make one-third of a revolution. The reason for not giving this example at an earlier stage is obvious: it would not have been consistent with the example of the "flyer leading," in which case we saw that the bobbin must increase in speed as it enlarges; it was therefore considered preferable to explain the matter in the first instance on the general principles applicable to both cases. The above illustration, however, is a very valuable one as enumerating the principle of the example when the bobbin leads, but a warning must be given that such a reduction in speed as is there mentioned never actually occurs in a fly-frame, although a greater difference than 3 to 1 exists between empty and full bobbins.

It must be firmly impressed upon the reader's mind that reduction in speed as the bobbin fills relates only to that portion of its speed which is in "excess" of the speed of the flyer. An example of this may be seen in Fig. 78, where the empty bobbin turns half a revolution while the flyer only turns a quarter. Now the full bobbin is clearly more than twice the size of the empty one, and yet its speed is obviously more than half what it was originally. Such a result is very puzzling to those who rely upon the conclusions drawn from the simple illustration given, without considering its real application. In Fig. 78 the point to notice carefully is that the excess speed of the

empty bobbin over the flyer is represented by the angle C E A^1, shown bordered by the black line, and indicating the amount of roving wound on, when the bobbin is full, and over twice the diameter of the empty bobbin. Its excess speed is shown by the angle C^1 E A^2, which is, as it ought to be, less than half of C E A^1, and is bordered by exactly the same length of an arc as on the smaller circle. It may be added that, no matter how large the bobbin, its speed would never be reduced to one-half, and the excess speed, although gradually reduced, would never be eliminated.

Principle of Winding.—We can now make a closer inquiry into the reduction of speed necessary for winding on the same amount of roving on different diameters of bobbin. Suppose that Q (Fig. 79) represents the bobbin, and that, after a number of revolutions, its excess speed over the flyer has enabled it to wind the roving once round itself, as at A B. Further layers are added, as at C E G, etc., and the question is—What reduction must take place in the excess speed at these points in order to wind on the same length of roving? It is quite unnecessary to give the actual calculation required to obtain it, it is sufficient to point out that since the excess speed is represented by the length wound on, its amount can easily be found for any given diameter. For instance, the outer circle at T was 7 in. diameter in the original drawing, and the smaller circle 1 in. diameter; so that one-seventh of the large circle equals the full circumference of the inner one. This is what is shown in the diagram at T U; at 4 and 5 the circle is 4 in. in diameter, consequently one-fourth of its circumference equals A B, and for the same reason the circle 2, 3, which is 2 in. in diameter, has half its circumference marked off as equal to the circumference

of Q. Any of the other points can be found in the same manner, and this becomes a very simple matter indeed when we recognise the principle underlying the diagram, which may be expressed as follows:—As the diameter of the bobbin increases, its rate of revolution must be reduced

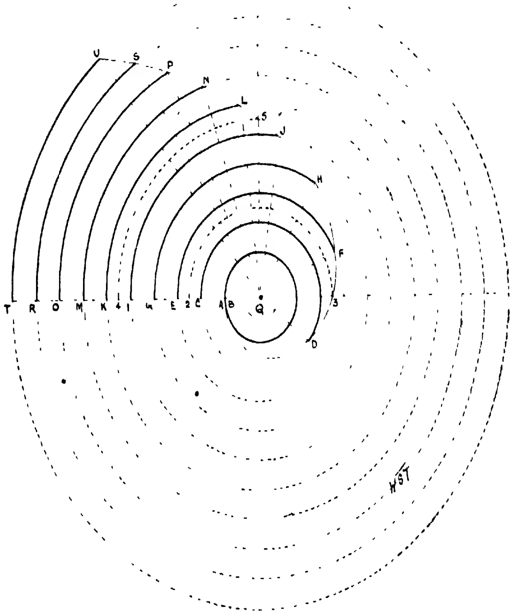


Fig. 79.

in inverse ratio; for, as just shown, twice the diameter requires half the speed, four times the diameter, one-quarter the speed, etc. The diagram (Fig. 79) is constructed in this manner, and the amount of each circle or diameter occupied by a similar length of roving is shown by the thickened line; the ends are joined by a curve,

which accurately defines the limits of the roving, equal to the circumference A B. This curve is a most important factor in designating the values of the varying speeds for the different diameters, and it is evident that its foundation depends on the intersection of the radial lines U Q, S Q, etc., with their respective circles U T, S R, etc. These radial lines form angles with the foundation line T Q, while the length of the arc is the same in all the circles; the angles enclosed by it vary considerably, and it is their variation that produces the curve. By plotting out this curve, either by taking the angles for our values, or by taking the proportion of the circumference occupied by each arc as our basis, and calling the smaller circle one, we obtain the curve represented in Fig. 80. In this form the curve presents its true characteristics, and it is at once seen to be a hyperbola. In the first place, it was made from the angular values in the following manner: a line, T A, was taken and divided into parts equal to the layers on the bobbin in Fig. 79, perpendicular lines were erected at the points of division, and on them were marked off lengths equal in value to the various angles; A B, for instance, represents 360°, because a full circle at Q contains 360°; again, at T U, this line represents 51° 25′ 43″ as equal to the angle T Q U, and so on with the other lines. In order, however, to adapt it to the other method, the length T A has been made equal to the full diameter, 7 in. At each inch, then, erect a perpendicular, and make the one at A B any convenient length. The length of the others can readily be obtained as follows:—Call A B one, as representing an inch in diameter; each division will then be numbered as two, three, four, etc., up to seven, and will be the corresponding inches from the end of the line A. The increase in diameter will therefore be repre-

sented on the horizontal line, and the decrease in speed on the vertical lines, and these latter will be reciprocal to the former. For instance :—

Diameters are	1 in.	2 in.	3 in.	4 in.	5 in.	6 in.	7 in.
Speeds will be	1	$\frac{1}{2}$	$\frac{1}{3}$	$\frac{1}{4}$	$\frac{1}{5}$	$\frac{1}{6}$	$\frac{1}{7}$
Represented as	AB	$\frac{1}{2}$AB	$\frac{1}{3}$AB	$\frac{1}{4}$AB	$\frac{1}{5}$AB	$\frac{1}{6}$AB	$\frac{1}{7}$AB

It will be noticed from the above that this relation must always hold good, viz. the diameter multiplied by its speed must always give the same result throughout the building of the bobbin. By carefully measuring the

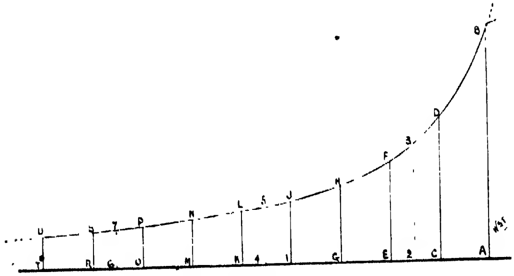


FIG. 80.

diagram (Fig. 80), or making a new one, the following relationship between the speed and diameter will be found to hold good :—

At A = 1 in. dia., has its speed A B represented by AB.

At 2 = 2 in. dia. (twice the dia. of A), has its speed 2 3 represented by $\frac{1}{2}$ A B.

At G = 3 in. dia. (three times the dia. of A), has its speed G H represented by $\frac{1}{3}$ A B.

At 4 = 4 in. dia. (four times the dia. of A), has its speed 4 5 represented by $\frac{1}{4}$ A B.

At M = 5 in. dia. (five times the dia. of A), has its speed M N represented by $\frac{1}{5}$ A B.

At 6 = 6 in. dia. (six times the dia. of A), has its speed 6 7 represented by $\frac{1}{6}$ A B.

At T = 7 in. dia. (seven times the dia. of A), has its speed T U represented by $\frac{1}{7}$ A B.

We may now summarise this explanation as follows:—

In order to wind on the roving, the bobbin must always have a greater speed than the flyer (bobbin leading).

As the bobbin increases in diameter this excess speed must be decreased.

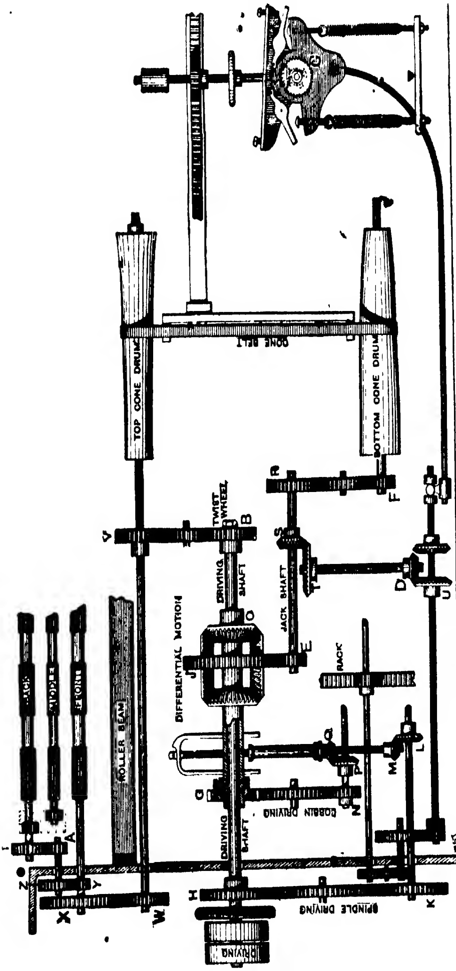
The reduction in the excess speed must be the reciprocal of the increase in diameter: for instance, if the bobbin be made twice the diameter, its excess speed must be reduced to one-half; if the increase in diameter be three times, the excess speed is reduced to one-third, etc.

The curve representing the combination of an increase in diameter with a reciprocal decrease in speed is known as the "hyperbola."

The variation in the speed of the bobbin as it increases in diameter must be consistent with the principles of the above curve.

Driving the Bobbins.—In applying the arguments just concluded to the actual operation of winding, it will be unnecessary to refer to previous methods. At the present time one system is practically universally adopted of effecting the required change in the speed of the bobbin, viz. by the use of cone drums, on the same principle as in the scutcher and opener. On reference to Fig 81 (which exhibits the full gearing of the fly-frame) it will be noticed that the spindles are driven direct from the driving shaft through the wheels H, K, L, and M. It will also be seen that the bobbins are driven direct from the same shaft through the bevel Q, which is fixed to the shaft and forms one of an epicyclic train of wheels, called a "differential motion." The wheel G is connected with this, and from here the bobbins are driven through the wheels N, P, and Q. As near an approach as possible is given to the speed of the spindle and bobbin consistent with the function of

the differential motion, and it must be carefully noted



GEARING PLAN OF FLY FRAME.

FIG. 81.

that both, to this extent, are driven direct by positive gearing.

Cone Drums.—The excess speed of the bobbin must now be considered. Cone drums are introduced, one of which is driven from the driving shaft through B and V, the bottom one being connected to the differential motion by the wheels F, R, and E. This has the effect of giving the necessary "additional" movement to this motion (the action of which will be subsequently made the subject for examination), and this excess speed is transferred to the bobbin through the wheels previously mentioned.

The statement was made in some previous remarks that the amount of roving wound on the bobbin represented the excess speed of the bobbin over the flyer, so that if a bobbin starts with a certain excess speed, its reduction must take place inversely to its increase in diameter. If, therefore, the full bobbin be four times the diameter of the empty one (which is about the limit in fly-frames), the excess speed must be reduced to one-quarter. This gives a basis to work upon, and there is no occasion to know the actual number of revolutions of this speed, as it is merely a question of gearing, and need not be taken into account in constructing the cone drums for their special purpose. Let us take for illustration the empty bobbin as being 1 in. in diameter and the full bobbin as 4 in. in diameter. This will mean that the diameter of the cone drums must be arranged to give a reduction of four from one extreme to the other. The diameters suitable for this, which several of our principal machine makers adopt, are: $3\frac{1}{2}$ in. for the small end, and 7 in. for the large end of each cone drum. When the strap is on the large end of the top cone and driving the small end of the bottom one, the bare bobbin is winding. As layers are added the strap is moved gradually by a special appliance to the other end, where a small diameter of the top cone drives the large end

of the bottom cone, in which case the largest diameter is winding on the roving.

Formation of Cone Drums.—Two diagrams are given in Figs. 82 and 83 to illustrate the further reasoning and to show its result graphically. In order to reduce the question, at first, to its simplest form, the speed of the bare, middle, and full bobbin will be found, each of which is represented by A, B, and C respectively in Fig. 82; these diameters may be taken as 1 in., $2\frac{1}{2}$ in., and 4 in. The top drum is the driver, and, for simplicity, it is

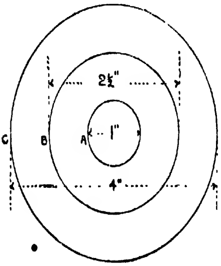


Fig. 82.

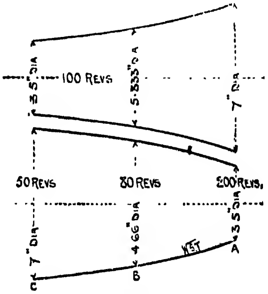


Fig. 83.

assumed to run at a constant speed of 100 revolutions per minute. The extreme diameters E and D will therefore drive the bottom drum diameters G and F at 200 and 50 revolutions per minute respectively. The middle speed is readily found, for, since the diameter is $2\frac{1}{2}$ in., which is $2\frac{1}{2}$ times larger than the empty bobbin, the speed must therefore be the reciprocal of this, which is $1 \div 2\frac{1}{2}$. Or perhaps a more simple way of putting it would be to say that the speed must be the inverse of this increase, $2\frac{1}{2} = \frac{5}{2}$; so its inverse order would make it $\frac{2}{5}$. Now, $\frac{2}{5}$ of 200 (the speed which drives the empty bobbin) = 80 revolutions; consequently the top cone must drive the bottom cone at this

speed when the strap occupies the central position. An important point to notice here is the great reduction in speed that has taken place from the speed of the bare bobbin, and how small this reduction becomes as the bobbin fills. It will serve to impress the reader with the obvious lesson to be learnt from the hyperbolic curve given in Fig. 80, where the reduction in speed is shown, by the quick descent of the curve, to be very rapid for the first layers, and then by the more gradual curvature to diminish at a slower rate as the bobbin gets fuller. It is now merely a question of proportion to get the diameters to suit the speeds, remembering, of course, that the sum of the opposite diameters must be the same, viz. $10\frac{1}{2}$ in.: therefore—

$$\frac{100 \times 10\frac{1}{2}}{180} = 5\cdot833 \text{ in. dia. of bottom drum,}$$

and the corresponding diameter for the top drum will be $10\cdot5 - 5\cdot833 = 4\cdot66$ in. If diameters be measured on the diagram equal to these dimensions, and a curve be drawn through their extremities, we obtain the hyperbolic curve that is so characteristic of the cone drum: the top cone becomes depressed or concave in its outline, and the bottom one correspondingly becomes convex. This simple case will enable a more complete example to be the more easily understood, and this we now proceed to give.

The bobbin, as before, is 1 in. in diameter when empty, and 4 in. when full. In order to obtain a sufficient number of points through which to draw the correct form of the curves, the necessary diameters of the drums will be found for every quarter of an inch additional diameter of the bobbin. The lengths of the cone drums are at least thirty inches, and the strap is moved from one end to the other by the transverse motion, step by step, as each

layer is added. Then in the present example the cone drums are divided so as to show the position of the centre of the strap for each diameter of the bobbin. This gives us thirteen position lines for which diameters are required, but, as the two end ones are known, viz. $3\frac{1}{2}$ in. and 7 in., only eleven require calculating. As in the last illustration the top driving cone will be assumed to run at 100 revolutions, in which case the extreme speeds of the bottom cone will be 200 and 50 revolutions, corresponding to the empty and full bobbins respectively.

The following table presents in a very concise form the elements and method of calculating the speeds and diameters :—

A.	B.	C.	D.	E.	F.	G.	H.
in.	in.	in.		Revs.	in.	in.	in.
1	1	1	$1 \times 200 = 200$	100	3·5	7·0	$10\frac{1}{2}$
$1\frac{1}{4}$	$\frac{5}{4}$	$\frac{4}{5}$	$\frac{4}{5} \times 200 = 160$	100	4·038	6·462	$10\frac{1}{2}$
$1\frac{1}{2}$	$\frac{3}{2}$	$\frac{2}{3}$	$\frac{2}{3} \times 200 = 133·33$	100	4·5	6·0	$10\frac{1}{2}$
$1\frac{3}{4}$	$\frac{7}{4}$	$\frac{4}{7}$	$\frac{4}{7} \times 200 = 114·28$	100	4·9	5·6	$10\frac{1}{2}$
2	$\frac{2}{1}$	$\frac{1}{2}$	$\frac{1}{2} \times 200 = 100$	100	5·25	5·25	$10\frac{1}{2}$
$2\frac{1}{4}$	$\frac{9}{4}$	$\frac{4}{9}$	$\frac{4}{9} \times 200 = 88·88$	100	5·5	5·0	$10\frac{1}{2}$
$2\frac{1}{2}$	$\frac{5}{2}$	$\frac{2}{5}$	$\frac{2}{5} \times 200 = 80$	100	5·83	4·67	$10\frac{1}{2}$
$2\frac{3}{4}$	$\frac{11}{4}$	$\frac{4}{11}$	$\frac{4}{11} \times 200 = 72·72$	100	6·078	4·42	$10\frac{1}{2}$
3	$\frac{3}{1}$	$\frac{1}{3}$	$\frac{1}{3} \times 200 = 66·66$	100	6·3	4·2	$10\frac{1}{2}$
$3\frac{1}{4}$	$\frac{13}{4}$	$\frac{4}{13}$	$\frac{4}{13} \times 200 = 61·5$	100	6·5	4·0	$10\frac{1}{2}$
$3\frac{1}{2}$	$\frac{7}{2}$	$\frac{2}{7}$	$\frac{2}{7} \times 200 = 57·14$	100	6·68	3·82	$10\frac{1}{2}$
$3\frac{3}{4}$	$\frac{15}{4}$	$\frac{4}{15}$	$\frac{4}{15} \times 200 = 53·33$	100	6·84	3·66	$10\frac{1}{2}$
4	$\frac{4}{1}$	$\frac{1}{4}$	$\frac{1}{4} \times 200 = 50$	100	7·0	3·5	$10\frac{1}{2}$

A are the actual diameters of the bobbin in inches.

B are the diameters of the bobbin expressed fractionally.

C represent the reciprocals of the figures in column B, and are expressed by reversing the order of the fractions in that column. These fractions represent the speeds in the same way as column B represents the diameters.

D column gives the speeds of the bottom drum as the

various diameters of the bobbin are built up. They are found, as shown, by taking the fractional proportion of 200 revolutions for each diameter, as represented in column C.

E gives the corresponding speed of the top cone drum, which is constant.

F gives the calculated diameters of the bottom cone drum. These are found by a simple proportion, as follows:—If the sum of two opposite speeds equal the sum of two opposite diameters corresponding to them, what diameter will equal either of the two speeds which make up the sum? Example (for 1 in. diameter):—

$$\frac{\text{Top speed} \times \text{sum of the dia.'s}}{\text{Top speed} + \text{bottom speed}} = \text{dia. of bottom cone drum.}$$

(1 in. dia. of bobbin) $\frac{100 \times 10\frac{1}{2}}{100+200} = \frac{1050}{300} = 3\cdot5$ in. dia.

(2 in. dia. of bobbin) $\frac{100 \times 10\frac{1}{2}}{100+100} = \frac{1050}{200} = 5\cdot25$ in. dia.

(3 in. dia. of bobbin) $\frac{100 \times 10\frac{1}{2}}{100+66\cdot66} = \frac{1050}{166\cdot66} = 6\cdot3$ in. dia.

(4 in. dia. of bobbin) $\frac{100 \times 10\frac{1}{2}}{100+50} = \frac{1050}{150} = 7$ in. dia.

G represents the diameters of the top cone drum, which are found by subtracting the diameters of the bottom cone drum from $10\frac{1}{2}$ in.

H is the sum of the opposite diameters. It is scarcely necessary to point out that this is requisite in order to allow the strap to fit regularly throughout the length of the cone drums.

Figs. 84 and 85 embody the above tabulated results. When the strap is at A the empty bobbin is being driven. By the time a quarter of an inch increase in diameter has been made the strap has been moved to B, and so on the full length of the drums, equal divisions representing equal increases in the diameter of the bobbin.